The Agricultural Journal of India

EDITED BY

The Inspector-General of Agriculture in India

ASSISTED BY

An Advisory Committee of the Staff of the Agricultural Research Institute,
Pusa, Bengal, India

VOL. I

CALCUTTA
THACKER, SPINK AND CO

1906

CALCUTTA
PRINTED BY THACKER, SPINK AND CO

TABLE OF CONTENTS.

VOL. I. 1906.

PART I.

PART II.

PART IV.

INDEX TO VOL. I.

1906.

A.

B.

D

E.

I.

PAGE.

S.

THE DEPARTMENTS OF AGRICULTURE IN INDIA.

By F. G. SLY, I.C.S.,

Offg. Inspector-General of Agriculture in India.

For administrative purposes British India is divided into provinces each with a Government of its own enjoying varying degrees of independence. The supreme authority in India is exercised by the Governor-General in Council, constituting an Imperial Government, or the Government of India as it is usually termed, to distinguish it from the separate Provincial Governments. With the Viceroy and Governor-General at its head, the executive council of the Government of India is composed of official members, who divide amongst themselves the control of the chief departments of State, the actual administration of which rests with the Provincial Governments. The organization of the Departments of Agriculture in India has naturally followed this main division of its general administration into Imperial and Provincial Departments.

* Leaving aside spasmodic efforts made by the East India Company and the Government of India on isolated occasions for special purposes, such as the cotton experiments of 1840 and the establishment of the tea industry in 1835-55, the policy of creating a special department to investigate the general conditions of agriculture was first recommended by the Commission appointed to inquire into the Bengal and Orissa Famine of 1866. This resulted in a scheme for the formation of a new department 'to take cognizance of all matters affecting the practical improvement and development of the agricultural resources of the country', which should consist of a separate department under the control of an official Director in each province, upon whom would devolve 'the real work of studying and improving agriculture,' and of a central Imperial Department of the Government of

* This historical summary is compiled from Government of India Resolution, No. 3-37-21, dated the 20th March 1897, and Chapter I, Voelcker's "Improvement of Indian Agriculture," to which readers desirous of more detailed information are referred.

India to guide and control the work of the Provincial Departments. A new branch of the Imperial Government was thus formed in 1871, but with the exception of the creation in 1875 of a Provincial Department in the North-West Provinces (now the United Provinces), there was a lack of provincial co-operation, with the result that the Imperial Department was abolished in 1879, during a time of great financial stress.

A second start was made as the result of the recommendations in the Famine Commission Report of 1880. An Imperial Department of Land Revenue and Agriculture was again created in 1881, followed by the organization in each province of a Provincial Department of Land Records and Agriculture under a Civilian Director. The duties were defined as '*agricultural inquiry, agricultural improvement and famine relief.*' For many years the work was almost wholly confined to the first and third duties. Most attention was given to the improvement of the system of the assessment and collection of the revenue levied by Government upon the land. The energies of the departments, both Imperial and Provincial, were also absorbed in measures for the improvement of the Land Records branch, which includes the collection and examination of annual statistics of the important agricultural and economic facts of each village, district and province. A machinery for the continuous collection of facts concerning the agriculture of the country was thus organised, which is second to that of no other country in the world. Annual statistics are published showing the area cultivated, fallow and waste; the area under irrigation; the area under each important crop; the number of live stock, ploughs and carts; the incidence of the land revenue on area and population; the transfers of land by proprietors and tenants; estimates of the yield of important crops, and the like. The necessity for the utilization of the facts and statistics obtained from the Land Records has always been borne in mind. It is the Director's duty to act as intelligence officer to the Government, to advise how agriculture may be maintained at the highest attainable standard of efficiency, and how deterioration may be prevented as well as improvement attained. A continuous analysis of all the information should be made to see what are the agricultural defects, and how they can be remedied; to give prompt and continuous information of *occasional failures* due to unforeseen calamities, such as hail, frost and the like; to ascertain *general failures* or deterioration of the prosperity of the tract due to general causes, such as interference of the drainage by railways or canals, spread of noxious weeds, cattle murrains and the like; to inquire into *persistent failures* to reach the highest standard due to persistent causes or defects, such as precariousness of the rainfall, want of irrigation, plant

diseases and blights, saline efflorescence and the like. In short, a continuous agricultural analysis should be made to throw light on all agricultural matters and the possibilities of improving the resources of the country.

In carrying out the duty of "famine relief," the first step was the publication of codes detailing the principles and measures to be followed in the relief by the State, of distress caused by famine. The duty of Provincial Departments is not only to provide the administration responsible for dealing with famine with the fullest information regarding the condition of every agricultural tract and its people, but also in seasons of scarcity to give prompt and continuous intelligence of the state of every village, and to assist in the actual work of relief.

The remaining duty of "agricultural improvement" was, however, postponed, until the organization of the Land Records system was sufficiently advanced to furnish facts on which it could be based. The Provincial Departments were unable to make much progress mainly because they were not given a staff of specialists skilled in agriculture and its allied sciences. A few experiment stations and model farms were established in some provinces, but these progressed slowly in the absence of skilled supervision. The Provinces of Bombay and Madras took the lead by employing expert agriculturists. Some advance was also made in agricultural education by the establishment of Agricultural Colleges at Poona (Bombay) and Saidapet (Madras), and Agricultural Schools at Nagpur (Central Provinces), Cawnpore (United Provinces) and Sibpur (Bengal). The professorial staff at all these Institutions was, and is, inadequate, so that their influence on agricultural improvement has been small. Their main result has been to turn out students with some knowledge of agriculture, who have mostly been absorbed into the several branches of Government Revenue administration.

An important step forward was made in 1889 by the deputation to India of Dr. J. A. Voelcker, PH. D., B.A., B.SC., F.I.C., &c., Consulting Chemist to the Royal Agricultural Society of England, to inquire into and advise upon the improvement of Indian Agriculture by scientific and other means. He remained in India from December 1889 to January 1891, visiting all its provinces, except Burma, and his report submitted in 1893, entitled* "The Improvement of Indian Agriculture" is still the standard, if not the only general work on the subject. It is impossible in this short article to give even a summary of the many important recommendations made by Dr. Voelcker. Suffice it to say that he pressed for the organization of a department, whose

* "The improvement of Indian Agriculture" by J. A. Voelcker, 2nd edition, published at the Government Press, Calcutta; price Rs. 2-8-0.

main duty would be the application of science to Indian Agriculture. The immediate outcome of Dr. Voelcker's visit was the appointment of an Agricultural Chemist (with an assistant) in 1892, whose main duty was to be the professional adviser of Provincial Departments.

From this modest beginning the organization of the Imperial and Provincial Departments of Agriculture has made rapid progress during recent years. The Provincial Departments have employed additional experts, and have opened additional experiment stations. The Imperial Department was strengthened in March 1901 by the appointment of a Cryptogamic Botanist, for the investigation of life in the soil in general, and fungus diseases of plants in particular. In October 1901 an Inspector-General of Agriculture was appointed to be the head of the Imperial Scientific Staff and the Principal Scientific Adviser of the Provincial Departments. An Entomologist was added to his staff in 1903. A most important development occurred in 1903, when the Government of India sanctioned the formation of an Imperial Agricultural Research Station, which includes fully equipped laboratories for research work, an experimental farm, a Higher Agricultural College and a cattle-breeding farm. This Institute is located on a Government estate of 1,358 acres, situated at Pusa in Behar, the most thickly populated agricultural tract of the Bengal Presidency, which will be the head quarters of the Imperial Scientific Staff. A full staff of European specialists with native assistants has been engaged. Apart from the value of the estate, the buildings now in progress will cost some 16½ lakhs of rupees (£110,000), towards which has been applied a portion of the munificent donation of £30,000 made by Mr. Phipps, an American gentleman, who during a visit to India placed this gift at the disposal of His Excellency the Viceroy Lord Curzon. The main building will include fully equipped laboratories for all the specialists, herbarium, museum and library, together with hall, lecture rooms and laboratories for the students of the College. The farm will provide experimental cultivation for the research work, and practical training for the students ; it is hoped that it will serve as a model for similar stations under Provincial Departments. The Agricultural College, with a full staff of professors and assistants, will provide a specialised post-graduate agricultural education, in the hope that the best of the native students will be ultimately fit for the higher appointments in the Agricultural Departments. It will also provide men with a good agricultural education for employment in the regular Government services, and by land owners as estate agents and the like. It is estimated that the College will be ready to start work about the end of 1907. The cattle farm is intended to provide a supply of good bulls for distribution to the adjoining tracts of Bengal, for the improvement of

the indigenous breed of cattle. It is thus intended that the expert staff of the Pusa Institute shall conduct higher lines of research work, applicable to all India and beyond the capacity of Provincial Departments, guide and assist the provincial experts in their several branches, train young scientists for future employment as provincial experts, and be the professors of the higher grade Agricultural College for all India.

A further opportunity for the co-ordination of the work of the Imperial and Provincial Departments, is afforded by the annual meeting at Pusa of the Board of Agriculture, which is attended by the Inspector-General of Agriculture and the Imperial staff, by the Provincial Directors and their staffs, and by the Inspector-General, Civil Veterinary Department, Director of the Botanical Survey and Director of Public Instruction, Bengal. This Board, presided over by the Inspector-General of Agriculture, discusses the programmes of the Imperial and Provincial Departments, and advises Government as to the action that should be taken for the improvement of Indian Agriculture.

The present constitution of the Imperial and Provincial Departments of Agriculture is shown in the table given at the end of this article. The Provincial Departments of Agriculture also include a Veterinary branch, which consists of one or more fully qualified officers (designated Superintendent, Civil Veterinary Department) with European degrees in veterinary science, and a large native staff of veterinary inspectors and assistants. Their principal duties are the investigation, prevention and cure of cattle disease, and the improvement of the breeds of cattle. There are numerous veterinary dispensaries in the towns, and much peripatetic work is done in the villages. Several cattle breeding farms have recently been started. There are also Veterinary Colleges at Lahore, Bombay, Madras and Calcutta, and schools in some other provinces. Whilst the provincial veterinary work is under the control of the Director of Agriculture, the Imperial branch of the Civil Veterinary Department is separate from the Imperial Department of Agriculture, being managed by a separate Inspector-General. The scientific staff of the bacteriological laboratories of Mukhteswar and Bareilly, which are under the control of the Inspector-General, Civil Veterinary Department, investigate the etiology of the important bacterial cattle diseases.

Mention may be made of some other State Departments which are separate in India, but are included in the Department of Agriculture of some countries. The great irrigation works of Government are managed by a branch of the Public Works Department. There are Imperial and Provincial Departments of Meteorology, which maintain observing stations (including solar, magnetic and astronomical observatories) for the supply of

information concerning weather conditions and prospects. A Botanical Survey of India has been in progress for many years under the Director of the Botanical Survey with the assistance of Botanical Officers. This work is largely confined to systematic botany dealing more with the collecting, arranging and identification of species and varieties of plants than with their economic and agricultural uses. The commercial products of India are investigated by the department under the Reporter on Economic Products; the "Dictionary of the Economic Products of India" is the achievement of ten years' patient work by Sir George Watt, Kt., M.B., C.M., F.L.S., C.I.E. The Geological Department of India maintains a strong body of experts both for the scientific examination of the Geology of India, and for the investigation of her mineral resources. Geography is represented by the important department of the Survey of India. Forestry is the province of the large Forest Department, which is one of the most important in the world.

In pursuance of the policy inaugurated by the formation of the scheme for the Pusa Institute, the important announcement was made in March last, that Government had decided to give for the expansion of the Departments of Agriculture an additional annual grant of Rs. 20 lakhs (£133,333), which it is hoped to increase in future years. This grant will permit of almost trebling the present expenditure. The general principles of the scheme of expansion have been considered, although there will necessarily be differences to suit the local requirements of each province. Subject to these differences, the outlines suggested for the reorganization of the department may briefly be stated.

In the first place an experimental farm is recommended for each important distinct agricultural tract. This will mean a very large increase to the farms enumerated in the appended table. Each farm will be in immediate charge of a trained native assistant with the necessary subordinate staff. It is proposed to strengthen the expert staff of each province so as to include one or more Superintendents of Farms, an Agricultural Chemist, Economic Botanist, Mycologist and Entomologist. The Superintendent of Farms (or Deputy Director as he has hitherto been designated) will be an expert agriculturist trained in general agricultural science and practical farming. He will be in charge of a circle, which will only be a part of a province in the case of large provinces, in which he will supervise all agricultural work, including the experiment stations, demonstration plots, the testing and distribution of seeds, implements and special manures. He must acquire a complete knowledge of the agriculture of his circle, and must be in close touch with the cultivators, so that he can answer their inquiries, give them advice on all agricultural matters and encourage them

to give effect to the results of successful research work. He must be the guiding spirit of the Agricultural Associations of his circle. His subordinate staff will include not only the establishment of the experimental farms, but a peripatetic staff to assist him in the performance of the duties outlined above. His head-quarters will usually be at the most important experimental farm of his circle. The other specialists will be located at the provincial Research Station, and will not only conduct research work in their laboratories and their head-quarters experimental farm, but will tour throughout the province, visiting all experiment stations, guiding the work connected with their special branch and inquiring into the local conditions of all tracts. The Agricultural Chemist will investigate all chemico-agricultural matters. The region in which the Agricultural Chemist will employ himself includes not only the chemical analysis of agricultural materials (such as soils, waters, manures, feeding stuffs, crop products and the like), but also the investigation of special problems. Amongst the problems ripe for investigation may be mentioned the exhaustion of the soil by the present modes of cultivation ; the amount of nitrogen in the rainfall and the loss of the soil constituents by drainage ; the nature, origin and removal of saline efflorescences ; the use of indigenous material for artificial fertilizers ; the sugar-content of different varieties of sugarcane and the causes affecting it ; the date and palmyra palm sugars ; the system of tobacco curing ; sewage from an agricultural standpoint. The duties of the Economic Botanist include an investigation of the economic uses of agricultural plants ; a botanical and biological study of the field and garden crops ; the testing of varieties ; the transfer of useful varieties from tract to tract ; the production of new and improved varieties by selection and cross-fertilization ; the testing of likely exotic plants. The Mycologist will study fungus life in the soil in its relations to plant food, and all fungus diseases of plants, amongst which may be mentioned wheat rust, linseed rust, potato blight, the pepper vine disease, red-rot in sugarcane, the wilt disease of the pigeon pea, rusts of millets, smuts of cereals, paddy diseases, the opium poppy blight, diseases of ginger, turmeric and egg plants, all of which cause great losses to the cultivator. The Entomologist will investigate the great number of insect pests injuring the crops and the means of introducing into general use practical remedies. For the present it will be necessary to fill most of these appointments with specialists recruited from Europe and elsewhere, but later on it is hoped that the Pusa College will provide suitable candidates from its best students.

A further proposal is that each important province should have an Agricultural College, which will give a technical education extending over

a course of three years. It is believed that the demand for passed graduates will be sufficient to induce a sufficient supply of students. There will be a large field for employment in the Department of Agriculture ; some may be employed in other branches of the State service, where a knowledge of agriculture will be of use ; it is also hoped that the sons of landowners will join in order to fit themselves for the management of their own estates and for employment as the managers of 'court of wards' and private estates. The expert staff will for the present be responsible for the teaching in addition to their research work, with the help of competent native assistant professors. This course in the provincial agricultural colleges will thus lead up to the post-graduate course of specialization at Pusa.

One important feature of the expansion scheme is the employment of an adequate subordinate staff in each branch, so that the superior officers may utilize their abilities on the more important duties and have plenty of assistants at their disposal. The staff will be graded so as to give prospects both in the lower and upper subordinate appointments equal to those in other branches of Government employ.

Further, it is hoped to improve the means of introducing the results of research work into general agricultural practice. Temporary demonstration plots will be started ; the formation of District Agricultural Associations will be encouraged ; Agricultural Shows will be supported ; the distribution of improved seed, implements and manures will be extended ; popular publications in the vernacular will be issued. There are many difficulties in the way of agricultural improvement in a country like India, with most of the land divided into minute holdings, and cultivated by small men with no capital and little education, but by these and similar means, it is hoped that the work of the department will be brought into close touch with the actual cultivators.

With this large expansion of the provincial departments, it is proposed to separate the Land Records branch, and to appoint a separate Director of Agriculture, who will for the present be a member of the Civil Service, to be in charge of the Agricultural and Civil Veterinary branches. He will be responsible for the general administration and discipline of the department.

Turning to the Imperial Department, the first proposal is to appoint supernumeraries to each specialist. These supernumeraries will be young men who, having completed their College education, will be posted to the Pusa Institute to undergo a further training under Indian conditions. They will be absorbed into the regular cadre of the departments as vacancies occur by leave or retirement. By this means it is hoped to avoid the existing difficulty of obtaining suitable candidates of experience.

It is also proposed to strengthen the Imperial staff by the employment of specialists required for the investigation of important special problems. There are investigations which cannot be confined within provincial limits without unnecessary duplication. In other cases Imperial experts are required to co-ordinate the work in each province, to assist the provincial experts by suggestions based upon their knowledge of the conditions in other parts of India, and the progress made in other provinces. Financial considerations also limit the number of experts which can be employed by each province. The additional specialists which have at present been suggested include a *cotton* expert, to co-ordinate the work in each province ; a *wheat* expert, to investigate the special problems of this crop, including the production of rust-proof varieties, cross-breeding experiments, the testing of varieties for special tracts, the milling and baking qualities of Indian wheats, the commercial requirements, and the like ; a *sugar* expert, to investigate the problems of sugarcane cultivation ; a *tobacco* expert, to introduce improved methods of cultivation and curing ; and a *fruit* expert, to improve the fruit cultivation and methods of packing and grading in the important fruit-growing temperate zone of North-West India. It is also proposed to employ additional Entomologists, who will be specialists in the more important groups of insects, for the subject is such a large one that the work must be divided amongst a strong central staff of systematists, a start being made by the employment of an expert in *Heterocera.*

Such are the outlines of the general scheme for the expansion of the Imperial and Provincial Departments of Agriculture, which has become possible with increased expenditure justified by the stability of exchange and the prosperity of the finances of the country. It must necessarily take some years to introduce it in its entirety, and experience will doubtless show the necessity for much modification, but within a reasonable period, the Departments of Agriculture in India should be raised to the position which they should rightly occupy in a country where the land revenue is such an important source of income, and where famine makes such appalling inroads on the national prosperity. The difficulties before the department are numerous and great, but it is an augury of ultimate success when one of India's shrewdest merchant princes has described expenditure upon scientific agriculture as the most promising investment that Government can make.

Table showing the constitution of the Imperial and Provincial Departments of Agriculture.

Province.	Staff.	Experimental Farms.	Educational Institutions.
IMPERIAL DEPARTMENT OF AGRICULTURE.			
Imperial ...	1 Inspector-General of Agriculture— Mr. J. Mollison, M.R.A.C. (Cirencester) (on leave); Mr. F. G. Sly, I.C.S. (offg.). 2 Assistant Inspector-General of Agriculture— Mr. T. F. Main, B.Sc. (Edin.). 3 Director of Agricultural Research Institute and Principal of Agricultural College, Pusa— Mr. B. Coventry (Beaumont College). 4 Agricultural Chemist— Dr. J. W. Leather, PH.D.; F.I.C.; F.C.S. 5 Cryptogamic Botanist— Dr. E. J. Butler, M.B. (Dublin), F.L.S. (Queen's College, Cork; University of Freiburg, and Kew). 6 Entomologist – Mr. H. M. Lefroy, M.A. (Cantab), F.E.S., F.Z.S. 7 Agri-Horticulturist— Mr. E. Shearer, M.A., B.Sc. (Edin.). 8 Agri-Bacteriologist— Mr. C. Bergtheil (University College, London, Nüremberg, and Agricultural College, Wye) on deputation under Bengal Government. 9 Biological and Economic Botanist— Mr. A. Howard, M.A. (Cantab), A.R.C.S. (Lond.), F.C.S., F.L.S., Diploma in Agriculture, Cambridge University, and Royal Agricultural Society of England.	1 Agricultural Research Institute, Pusa, Bengal (General Experiment Station).	1 Agricultural College, Pusa, Bengal.
PROVINCIAL DEPARTMENTS OF AGRICULTURE.			
Bombay ...	1 Director— Mr. H. S. Lawrence, I.C.S. 2 Deputy Director— ... Mr. F. Fletcher, M.A. (Cantab), B.Sc. (Lond.), Diploma, in Agriculture Cambridge University &c. 3 Economic Botanist and Professor of Botany, College of Science, Poona.— Mr. G. A. Gammie, F.L.S.	1 Kirkee, Poona, Deccan (General Experiment Station and Dairy Farm) 2 Mānjri, Poona, Deccan (General Experiment Station, principally sugarcane and sewage Farm). 3 Dhulia, Deccan (General Experimen Station, principally cotton).	1 College of Science, Poona.

Table showing the constitution of the Imperial and Provincial Departments of Agriculture—contd.

Province.	Staff.	Experimental Farms.	Educational Institutions.
	Provincial Departments of Agriculture—contd. 4 Professor of Agriculture, College of Science, Poona, and in charge of Kirkee and Manjri Farms—Mr. J. B. Knight, M.Sc. (Massachusetts College). 5 Agricultural Chemist—Mr. A. A. Meggitt, B.Sc. (Lond.). 6 Divisional Inspector, Sind (temporary)—Mr. Sidh Bisal Malhi, M.R.A.C. 7 Divisional Inspector, Deccan—Mr. G. K. Kelker, L. Ag. Bombay.	4 Surat, Guzerāt (General Experiment Station, principally cotton). 5 Nadiād Farm, Guzerāt (General Experiment Station, principally millets and tobacco). 6 Dhārwār, Karnātak (General Experiment Station, principally cotton and millets). 7 Mīrpur Khās, Sind (Cotton and Irrigation Station). 8 Lanauli, Deccan (Rice Experimental Plots). 9 Belgaum, Karnātak (Subsidized tree-cotton Experimental Plot). 10 Chhārodi, Guzerāt (Subsidized Cattle Breeding Farm). 11 Sholapur, Deccan (Cattle Breeding Farm).	
Madras ...	1 Director—Hon'ble Mr. A. E. Castlestuart Stuart, I.C.S., F.G.S., F.Z.S., F.R.G.S. 2 Deputy-Director—Mr. C. Benson, M.R.A.C. 3 Government Botanist—Mr. C. A. Barber, M.A. (Cantab), F.L.S. 4 Principal of Saidapet College.—Mr. Keess, M.A. (Cantab), M.R.A.C.	1 Samalkota, Godāvari (Sugarcane Station). 2 Koilpatti, Tinnevelly (General Experiment Station). 3 Bellary (General Experiment Station). 4 Hindupūr, Anantpur (Agave Fibre Station). 5 Taliparamba Malabār (Pepper Station). 6 Palur, South Arcot (Groundnut and Sugarcane Station). 7 Hágari (Irrigation Pumping Station).	1 College of Agriculture, Saidapet, Madras, with Farm attached.
Bengal ...	1 Director—Mr. N. D. Beatson Bell, I.C.S., B.A. (Oxon.) 2 Deputy-Director—Mr. F. Smith, B.Sc. (Edinburgh), F.H.A S. 3 Assistant Director—Mr. N. G. Mukerji, M.R.A.C. (Cirencester), M.A. (Calcutta). 4 Assistant Director—Mr. D. N. Mukerji, M.R.A.C. (Cirencester), M.R.A.S. (England), M.A. (Calcutta). 5 Superintendent, Siripur Farm—Mr. N. N. Banerji, M.R.A.C. (Cirencester), F.H.A.S., M.R.A.S. (Ireland).	1 Burdwān (General Experiment Station). 2 Dumraon (General Experiment Station). 3 Sibpūr, Calcutta (General Experiment Station. Also demonstration for agricultural lectures). 4 Siripūr, Hathwa (General Experiment Station and Cattle Farm). 5 Gouripūr, Mymensing (General Experiment Station). 6 Rampur Boalia (General Experiment Station). 7 Rangpur (General Experiment Station, principally jute and tobacco). 8 Chittāgong (General Experiment Station).	1 Agricultural School, Sibpur, Calcutta.

Table showing the constitution of the Imperial and Provincial Departments of Agriculture—concld.

Province.	Staff.	Experimental Farms.	Educational Institutions.
	Provincial Departments of Agriculture—concld.		
	6 Indigo Specialist—Mr. C. Bergtheil (University College, London; Nuremburg; Agricultural College, Wye.) 7 Jute Specialist—Mr. R. S. Finlow, B.Sc., F.C.S.	9 Cuttack (General Experiment Station, principally irrigation experiments).	
United Provinces of Agra and Oudh.	1 Director—Mr. W. H. Moreland, B.A., C.I.E., I.C.S. 2 Deputy-Director—Mr. J. M. Hayman, D.V.S. (McGill University, Diplomist of Guelph Agricultural College and Cambridge University). 3 Assistant Director—Mr. Saiyid Muhammad Hadi, M.R.A.C., M.R.A.S. 4 Economic Botanist—Mr. H. M. Leake, M.A. (Cantab), F.L.S. (Christ's College, Cambridge).	1 Cawnpūr (General Experiment Station). 2 Orai, Jalaun (General Experiment Station). 3 Gursikran (Station for reclamation of saline tracts). 4 Juhi (Station for reclamation of saline tracts.) 5 Abbāspur (Station for reclamation of saline tracts).	1 Agricultural School, Cawnpur.
Punjab ...	1 Director—Mr. W. C. Renouf, I.C.S. 2 Deputy-Director—Mr. S. Milligan, M.A., B.Sc. (Edin.).	1 Lyallpur Farm, Chenab Colony (General Experiment Station). 2 Sargodha Farm, Jhelum Colony (Seed Production).	
Central Provinces.	1 Director—Mr. C. E. Low, I.C.S., (offg.). 2 Deputy-Director Mr. D. Clouston, M.A., B.Sc. (Edin.). 3 Assistant-Director—Rai Bahadur R. S. Joshi, L.Ag. (Bombay.)	1 Nagpur (General Experiment Station, principally cotton; sewage farm; and cattle breeding farm). 2 Hoshangābād (General Experiment Station principally wheat; and cattle breeding farm). 3 Raipūr (General Experiment Station, principally rice).	1 Agricultural School, Nagpur.
Assam ...	1 Director—Mr. F. C. Henniker, I.C.S. (on leave), Mr. H. C. Barnes, M.A., I.C.S. (offg.). 2 Assistant Director—Rai Bahadur B. C. Basu, B.A., M.R.A.C., M.R.A.S. (England).	1 Shillong Farm and Fruit Garden (General Experiment Station, principally temperate fruits and vegetables and sericulture). 2 Wahjain (Experiment Station for Tropical Fruits and Plants).	
Burma ...	1 Director—Mr. J. A. Mackenna, I.C.S.		

MANURING SUGARCANE.

By J. WALTER LEATHER, PH.D., F.I.C.,

Agricultural Chemist to the Government of India.

"Good muck and plenty of it" is a sound old English adage in agriculture, and doubtless finds its counterpart among all sugarcane planters in India. Unfortunately its application is limited by the fact that the supply of farm-yard manure on any farm is sufficient only for a part of the crops grown, and must be supplemented in all countries by other materials destined to the same end. It necessarily follows that the economical use of manure for crops is a most important agricultural problem. It is a case precisely similar to that of any manufacturer who takes raw materials and derives from them finished goods. A broad distinction occurs, however, in the circumstance that in most cases of manufacture the processes are well under control, and a given quantity of raw material may be expected to yield a definite quantity of the finished article. In agriculture, on the other hand, no such comparative certainty exists. In part this is due (in the case of crops) to climatic conditions which are uncontrollable and affect outturns to a considerable extent. But apart from this, the effect of manures on crops is not characterised by that regularity which processes more under the control of the individual, exhibit. Nevertheless, a great object in agricultural research is to determine the conditions under which this or that 'manure' may be applied so as to attain the most economical result. At the present day this problem can only be attacked in what is styled an empirical manner; namely, definite quantities of the manures are applied to the land in question, and the effect gauged by the resulting crop. It is a simple method in principle, and although in reality very defective, has nevertheless rendered great service. It suffers from several interfering circumstances; the soil in question may not be uniform, the season may be quite abnormal, the period of applying the manure in relation to that of sowing the crop may be of considerable or of little importance, and finally what applies to one soil may not necessarily apply to another. Whilst the method then does not provide fine distinctions between one manure and another, general deductions of fair reliability and of great value are possible.

During the last decade, experiments on the manuring of sugarcane have been in progress at several of the Government farms in India, and the lessons to be learnt from these are of interest to those who engage in the industry.

That land which is destined for a sugarcane crop should be manured, is well known, and there are probably few places in India where the attempt is made to grow the crop entirely unaided. At the same time the very great variations in the size and nature of the crop that one meets with in different districts, shows only too plainly that the amount of cultivation and manure devoted to it differ within wide limits. Sugarcane crops may be seen in parts of the Punjab or the United Provinces or in Behar which have received little or no manurial assistance, whilst conversely in other districts of these Provinces, or still more generally in the Deccan or in the Madras Presidency, this crop is treated in that liberal manner which is one of the conditions necessary to ensure a high outturn.

It is well understood that the object of adding manures to the land is to supplement the supply of certain materials to the growing plant, which are in limited quantity already present in the soil. The plant foods which must be usually considered in this relation are potash, nitrogen and phosphates. This does not imply that the plant requires nothing else, but that the several other foods are already usually present in the soil or atmosphere in sufficiently liberal amount. Of the total weight of any green plant, over 90 per cent. consists of water derived from the soil, and carbonaceous material derived from the atmosphere. Organic nitrogenous matter, built up in part from the carbon dioxide of the atmosphere and in part from the nitrates in the soil, will amount to 1 to 2 per cent. of the green plant, and this includes about ·1 to ·3 per cent. of nitrogen obtained from the soil. Of the mineral constituents, potash, lime, magnesia, phosphates, &c., similarly low percentage quantities are met with. But whilst these quantities when expressed as percentages appear small, they not only amount to from 10 to 100 or more lbs. per acre, but in order to supply them, still larger quantities of manure are required, and if the crop be a heavy one, such as sugarcane should be, then the amount of manure required becomes really large.

The sugarcane crop will weigh, in the fresh state, from 20,000 to over 100,000 lbs. per acre, and it follows that the plant food required to build up such a great weight of crop, is correspondingly great. Like all green and immature crops, the composition of sugarcane varies within somewhat wide limits. Specimens examined during 1895 and 1896 showed that the fresh cane contains from ·02 to ·05 per cent. of nitrogen, and from ·04 to ·08 per cent. of phosphoric acid ; the green immature tops, which are usually cut off, from ·1 to ·3 of nitrogen and about ·1 of phosphoric acid ; and the dead

leaves from ·3 to ·5 per cent. of nitrogen, and ·2 to ·4 per cent. of phosphoric acid. If we calculate these quantities to lbs. per acre, it is found that a crop of 50,000 lbs. of cane, together with its tops and dead leaves, will contain some 50 to 100 lbs. of nitrogen and about 40 to 70 lbs. of phosphoric acid. Many cane crops in India weigh considerably more than 50,000 lbs., and not infrequently run up to 100,000 lbs. Thus the requirements of the crop cannot be stated precisely. The deduction may, however, be made that every 10,000 lbs. of clean cane grown, together with its tops and leaves, will remove from the soil some 10 to 20 lbs. of nitrogen and nearly as much phosphoric acid.

The next point of interest is the quantity of manure required to supply such crops. And here let it be noted in passing, that it is not a good agricultural practice to try to get as much out of the land as possible without making adequate return. In addition to the effect of the growing crop, other influences are generally present tending to lower the "fertility" of arable land, and it becomes a golden rule in all good farming, to apply as manure at least as much as the crop will assimilate, and indeed usually a surplus as well. This is a regular practice in Europe, where the manures used generally contain half as much again as the crop assimilates. And so too in the districts in India where the best cultivation prevails, we find very liberal ideas of manuring. Thus around Poona, Mr. Mollison estimates that as much as 30 tons of poudrette or farm-yard manure are used per acre for cane land (*vide* Agricultural Ledger No. 8 of 1898, p. 7). Such a quantity of manure will contain about 300 lbs. of nitrogen and even more phosphoric acid and potash, *i.e.*, quantities largely in excess of the requirements even of the heavy crops of that neighbourhood. It follows that one of the most interesting matters in relation to sugarcane planting, is the quantity of manure which should be used per acre. The materials at our disposal are numerous, and possess moreover widely different values per maund or per ton. For example 100 parts of cattle dung rarely contain so much as 1 part of nitrogen, usually indeed only about one half or two-thirds of a part, whereas the much more concentrated fertilizers, the oil-cakes or fish-manure, contain from 4 up to 10 parts. The amounts of potash and phosphate will vary in a very similar ratio. It becomes necessary, therefore, to distinguish between our several manures and to use them in quantities corresponding to their relative richness. In fact we require to know how much oil-cake or fish manure is equivalent to a ton of farm-yard manure.

It has been found that for many soils the outturn of crops of the *gramineæ* depends mainly on the amount of nitrogen present in the manure, provided this belongs to the category of the so-called "organic manures,"

such as farm-yard manure, poudrette, the oil-cakes and the like. These all contain other elements of plant food and generally in quantity corresponding to the nitrogen, so that if sufficient of the latter element is provided, it may be assumed that the supply of the others will be similarly liberal. Such an assumption simplifies in a great measure the comparison of manures when the crop belongs to the natural order mentioned. Thus in order to compare farm manure with castor poonac, it is sufficient to compare their relative richness in nitrogen ; if the former is found to contain ·5 per cent. and the latter 5·0 per cent. then the latter may be held to be approximately 10 times as valuable as the former, or that we require only one-tenth as much per acre. It has been necessary to digress somewhat in order to make it clear to the reader why, in relation to the sugarcane crop, manures are so constantly appraised on the basis of their nitrogen content, and why so little mention is made of the amount of potash or phosphates which they contain.

The most extensive series of experiments on this subject are those which were made at the Manjri farm near Poona between the years 1894 and 1903. The soil is "black-cotton" of the Deccan type, varying from about 2 to 6 feet deep, and resting on the semi-decomposed trap called "Murum." It is a good soil and freely open to drainage. It will be most convenient if the crops produced by the individual manures are considered separately.

Taking as a basis the general practice of the district, large amounts of manure were employed, and the local "Pundia" variety of cane was cultivated. During the eight years of the experiments, freshly planted cane was grown four times ; two ratoon crops were taken, and twice jowar was grown as a rotation crop. The manures used may conveniently be divided into three classes, namely, farm-yard manure, poudrette and fish manure ; secondly, the oil-cakes ; and thirdly, bones and saltpetre.

Farm-yard manure and *poudrette* both contain only low proportions of fertilising ingredients, and large amounts are, therefore, required ; 20 to 25 tons were used per acre, containing, it was estimated about 500 lbs. of nitrogen. If these are admittedly very heavy applications of manure, the yield of cane and sugar were also large. From two plots the outturn varied from 6,000 lbs. up to over 11,000 lbs. of "gul" (raw sugar) ; the effect of poudrette was even greater, and from 10,000 to over 13,000 lbs. was realised. The ratoon crops were naturally somewhat smaller (5,000 to 8,000 lbs. "gul"). The effect of farm-yard manure was rather more gradual than that of the other materials ; it exhibited in fact one of its usual characteristics. Poudrette is well known to cultivators all over India.

Fish manure is not so widely known, but the demand for manure in the Deccan, and probably other parts of India not far removed from the coasts,

is so great that a trade in sun-dried refuse fish has sprung up. It is a concentrated manure, containing fully 10 times as much plant food per ton as farm-dung. The amount employed was 2·7 to 2·9 tons per acre, containing about 500 lbs. nitrogen, and the outturn of raw sugar varied from 11,000 to over 13,000 lbs.

Oil-cakes.—Passing from the foregoing materials, we come to the oil-cakes. Of these there are a great variety in India. Some of them, such as earth-nut, safflower, jingelly or cotton-seed, are valuable cattle foods; others such as castor, bassia or karanji possess a value only as manures. Curiously the value set upon the latter class of manures in the Deccan by the cultivator ten years ago, was comparatively greater than that which he placed on cattle foods. Thus at the time when the experiments were instituted, castor cake was selling at Rs. 51 per ton, whilst safflower cake commanded only Rs. 47, although it possesses a fertilising value nearly twice as great as Bombay castor cake. Other similar examples were cotton seed, niger cake and ground-nut safflower cake. It was thus cheaper to employ these valuable feeding materials as manure, than castor cake or karanj cake. Naturally their fertilising value per ton differs within considerable limits. Safflower cake may be said to be the best, and if its value be denoted by 10, the others may be valued as follows: cotton-seed cake, 4·4; niger cake, 7·3; mixed safflower and ground-nut, 9·5; castor poonac (Bombay), 5·4; and karanj, 4·4. The cost of these oil-cakes in quantity corresponding to the farm manure was about Rs. 160 for safflower or safflower and ground-nut cake, Rs. 280 for karanj, and Rs. 300 for castor poonac or cotton-seed cake. The yields of sugar obtained by the use of castor poonac or karanj cake varied from 9,000 to over 12,000 lbs. per acre; those from safflower or niger cake plots from 11,000 to over 13,000 lbs. per acre; and cotton-seed yielded generally as much. It must, however, be recollected that since these are expensive materials, the relative values per ton which have been stated above, must be considered in relation to the local market price, before deciding which to purchase. For example if the price of castor poonac, with a relative value of 5·4, were Rs. 50, and that of karanj, the relative value of which is 4·4, were Rs. 42, the castor is slightly the cheaper; and if safflower cake is obtainable at Rs. 60, then it is much the cheaper of the three.

The oil-cake from the seed of bassia latifolia (the Mohwa tree) deserves a special remark. Per ton it is the least valuable of the several oil-cakes used, but being a refuse material, it is cheap. It was employed for two years, and on the first occasion the cane sets did not germinate. They were replanted a month later, when germination followed perfectly well. No further difficulty was experienced with it. The yield of sugar, 7,000 lbs. per acre, compared

fairly well with that from the use of other manures. It is possible that this press-cake includes a constituent which affects germination, but if so, it has not so far been recognised.

But whilst these applications of the oil-cakes as manure proved so very effective, and although the cost of the manure, namely from about Rs. 150 to Rs. 300 per acre, was not considered excessive or more than the cultivators were spending, it was neverthless apparent that the quantity of manure was very largely in excess of the requirements of the crop. Accordingly some other plots were devoted to smaller applications of the same materials. The following are the principal results (1899-1900) :—

Plot.	Manure.	Weight of Nitrogen. lbs. per acre.	Raw sugar obtained. lbs. per acre.
33	Niger cake	500	9,180
34	,, ...	350	9,180
35	Safflower cake	500	9,305
36	,, ...	350	8,700
37	Farm-yard manure ..	500	9,925
38	,, ...	350	9,145
43	Poudrette	500	8,420
44	,, ...	350	8,160
45	,, ...	250	6,805

These experiments, though only made for the one year, lent support to the theory that the very high rates of manuring practised in the district, were perhaps unnecessarily large, and the conclusion has been drawn, that for the land in question, namely, Deccan black cotton soil, manure containing some 300 to 350 lbs. of nitrogen, together with the phosphates and potash present in the materials named, should be sufficient to ensure a heavy crop of cane. Naturally it is assumed that the land is in good " tilth" and first class order.

Other materials have also been employed as manure for the sugarcane crop at Manjri. *Bones*, both in the form of powder, and also after conversion into superphosphate by the agency of sulphuric acid, were used ; and on other plots saltpetre was also added.

The bones and bone superphosphate contained only one-fourth as much nitrogen as the oil-cakes of the neighbouring plots, and where saltpetre was used in addition, the mixture contained only one-half as much nitrogen as the oil-cakes. It was, therefore, hardly to be expected that full crops would be obtained; and this expectation was fulfilled, for with manure containing only 130 lbs. of nitrogen, the yield of raw sugar was 4,000 to 7,000 lbs.; with the mixed manures containing 250 lbs. of nitrogen, 5,000 to 9,000 lbs. of sugar were obtained. It may be added that in one year when larger amounts of these manures were used, the outturn came into line with the largest crops of

the series, a fact which negatives any suggestion that the lesser outturn might be referred to the nature of the manure rather than to its weight.

These experiments did not include mixtures of bones or superphosphate with the so-called organic manures. In fact, since these generally contain an amount of phosphate corresponding to the nitrogen, it is useless on the generality of land to expect any marked advantage in the use of such mixtures. At the same time there are soils which are abnormally poor in phosphate, and in such cases it might pay to add to an oil-cake one-twentieth part of its weight of bone superphosphate.

The effect of the several manures has been expressed by quoting the yield of raw sugar obtained, and the actual yield of cane has not been mentioned. On the whole this is to be preferred. The proportion of raw sugar per 100 parts of cane has, it is true, varied somewhat and occasionally seriously, as will be mentioned subsequently, but in the foregoing instances, the variation was only moderate, namely, from about 11 to 13 per cent.; that is, from each 100 lbs. of cane between 11 and 13 lbs. of raw sugar was obtained. The whole of the experiments were made with one variety of cane, namely, the "pundia," a yellow-green, very fine cane of about 4½″ to 5″ girth. About 70 per cent. of juice was usually obtained by double crushing.

The experiments at Cawnpore on this subject, which were made during the years 1897 to 1903, though not so exhaustive as those at Manjri, have yielded useful information on several points. The manures included farm-yard manure, poudrette, castor cake, bone meal plus saltpetre, and bone superphosphate plus saltpetre. Thus only one of the several oil-cakes was used. As was to be expected all these materials were found to be valuable fertilisers. There are two points of chief interest, for the moment, in these experiments. Firstly, the weights of crop and raw sugar were very much less throughout than that realised at Manjri. It is probable that the sugarcane crops in the Deccan are unusually heavy. They are much above what is considered to be an average in any country, and such heavy crops were not grown at any of the other farms. Those at Cawnpore were not more than half as heavy, and one can only conclude that there are features in the Deccan soil which in a measure account for this difference in yield. Secondly, the Cawnpore experiments provide somewhat more complete information on the subject of the most desirable quantity of manure to use than did those at Manjri.

Two plots of land were employed at Cawnpore, and cane was only grown in the alternate years on either ; some other crop—sometimes potatoes and sometimes the millet, *Panicum frumentaceum* (Savan), being grown without additions of manure in the alternate years. The description of cane grown was that known locally as "Madrasi paunda," a thick and

very good cane. The results obtained confirmed, in a great measure, the lessons derived from the plots at Manjri on which large and small quantities of manure were used. It is seen that at Cawnpore, as at Manjri, the heaviest manure dressing was unnecessary, whilst conversely the smallest was too small for the production of a maximum crop.

Average outturn of raw sugar from the plots at Cawnpore.

Manure.	Quantity used, tons per acre.	Containing Nitrogen. lbs. per acre.	Average yield of raw sugar, lbs. per acre.
Farm-yard-manure ...	8	125	4,594
Do. ...	16	250	5,014
Do. ...	32	500	3,928
Poudrette ...	30	250	3,836
Do. ...	60	500	4,086
Castor cake ...	1·7	250	4,056
Do. ...	3·4	500	4,905
(*a*) Bone dust and ... (*b*) Saltpetre ...	(*a*) 1·2 (*b*) ·5	125	3,785
(*a*) Superphosphate and (*b*) Saltpetre ...	(*a*) 1·9 (*b*) ·5	125	3,467

Top-dressing with Manures.—Under certain circumstances it is better to add a manure gradually during the period of growth, rather than to apply the whole to the land before sowing. Thus, in Europe, it is a very common practice, if saltpetre is to be used as a manure, to apply it to the crop either in part or altogether after the plant has grown some inches high. The *raison d'être* of this is very simple. Saltpetre is a very soluble material, and if drainage occurs through the soil, it is carried with the water. If then, it is applied to the land, like most manures, before sowing the crop, and the rainfall is abundant during the early stages of growth, the nitrate may be washed away to a stratum below the region of the roots, and would become lost. Thus, for example, in England, wheat is frequently sown during the autumn; the crop germinates at once, but the development of the plant is only slow during the ensuing winter, and becomes vigorous first when spring sets in. If then, nitrate were applied as a manure to the land *before sowing*, it might be largely washed by the winter rains below the area occupied by the roots at that time. It is therefore preferable to scatter it on the land at the beginning of the spring, when the rains of that period wash it into the soil and carry it to that position in which it is of greatest service. Other manures are sometimes dealt with similarly. For example at Woburn, farm-yard manure is scattered on the young wheat as a "top-dressing" in the early spring.

The case of sugarcane is somewhat similar. We have here a crop which enjoys a long period of growth, and constant additions of water,

either as rain or by irrigation, occur on the surface, which mostly soaks into the soil. Some at least passes away to the region of the underground water and carries nitrate with it. It is a common practice to apply manure for a *ratoon* crop, *after* the plant has made some progress (*vide* Mollison, Agricultural Ledger No. 8 of 1898, para. 63). The various experiments on the manuring of sugarcane in India, have not included any very systematic tests of the extent to which this practice of top-dressing with manure is advantageous, but it is probable that in certain tracts at least, such for instance as experience a heavy monsoon rainfall, with fairly open soil, the subject is deserving of more attention than it has received. It is to be remembered that even in the case of organic manures, farm-yard manure, oil-cakes and the like, the nitrogen of the material is converted into nitrate before the plant assimilates it. Supposing this process of nitrification takes place very rapidly, that the soil is very open, and the rainfall heavy, the valuable nitrate would be washed away out of the reach of the roots, before the plant had time to develop. Under such conditions it seems highly probable that it might prove an economical practice to put only a part of the manure on the land at the time of planting, and to dig in the remainder later on, after the crop had somewhat developed. On the other hand, in soils of a "close" nature, or where the amount of drainage is not excessive, there would not be the same danger of losing nitrate, and top-dressing would be correspondingly unnecessary.

The effect of manures on the juice.—So far we have considered the effect of manures on sugarcane, irrespective of the variety, and also without reference to possible effects that manuring may have upon the juice of the cane. In fact, we have considered gross outturns only. In the experiments referred to, there has been no objection to this, because the crops grew to perfection, and the yield of sugar was proportional to the gross weight of cane. At the same time the value of the sugarcane crop depends on three factors, namely, the weight of cane, the proportion of juice expressible by a mill, and the quality of the juice. The quality of the resulting "gur" will depend very largely on the third of these factors. An ideal crop of cane is one that fulfils the three conditions: great weight of cane; high yields of juice, about 70 parts or more of juice per 100 of cane; and juice containing a high proportion (16 per cent. or more) of cane-sugar, but very little (·5 per cent. or less) of glucose. It is, however, well known that the juice of cane may suffer from several causes: if the harvested crop is not mature, the juice will contain a high proportion of glucose; if the crop becomes "lodged" (broken down) through stormy weather for instance, the effects on the juice are similar; and a third cause tending in the same

direction is excessive manure. In the Manjri experiments, from which quotations have been made, it appears probable that the largest amounts of manure used were unnecessarily large, probably half as much again as was necessary to produce the heaviest crops. But the cane did not suffer, the crops grew to great perfection, and the "gur" was excellent. On the other hand instances have occurred both at Manjri and at Cawnpore, from which quotations will now be made, of cane having suffered from too heavy manuring.

The most conspicuous case is perhaps that of some varieties of *thin* canes, known locally as *ukh*, which were grown at Cawnpore. Three such varieties, together with three varieties of thick *pounda* canes, were grown for several years with quantities of manure corresponding to those which have been quoted. Poudrette was used in quantity 30 and 60 tons, sufficient to supply 250 and 500 lbs. of nitrogen respectively, per acre. The thin *ukh* canes are quite unaccustomed to such liberal manuring. Very heavy crops amounting to 30,000 up to 60,000 lbs. of cane were produced, but the cane was unable to bear its own weight, and fell down. The canes grew somewhat thicker than usual, and yielded more juice, but the latter contained less sucrose and more glucose than usual.

The effect on the juice was also readily discernible from the chemical analysis which was made in 1897. The juice of the "Matna" variety, when well matured, contains more than 16 per cent. of cane-sugar with about ·3 per cent. of glucose, whereas that produced on the heavily manured land contained from 8 per cent. up to 13 per cent. of cane-sugar and 1·5 down to ·7 per cent. of glucose. The other two *ukhs* contained similarly low proportions of sugar. The experiment was continued for six years with the idea of testing whether these varieties would gradually become accustomed to the conditions of high cultivation, but no evidence in support of this was adduced; the canes continued to yield heavily, but juice of only poor quality was obtained. It is an extreme case, and naturally must not be taken to indicate that sugarcane should not be liberally manured.

A somewhat similar instance occurred at the Manjri Sewage Farm in 1903. A moderately thick cane, the "Sannabile" of the Deccan, was grown on land irrigated with sewage. The quantity of the latter was much larger than was necessary for simple manurial purposes, and was controlled by other considerations. It was estimated from a series of analyses made during four months, that this land received 735 lbs. of nitrogen, 353 lbs. of phosphoric acid and 274 lbs. of potash per acre in the sewage. As at Cawnpore, so here, the cane grew to such luxuriance that it could not support itself, and the crop became "lodged." The result was that, although the crop was heavy (the

raw sugar outturn was about 9,000 lbs. per acre), the quality of the raw sugar was, in part, anything but good. It was noticed at an early stage of these particular experiments that irrigation with sewage must cease a couple of months prior to the time when the cane ordinarily ripens, for otherwise, the forcing effect of the manure tended to prevent it, in a measure, from doing so satisfactorily.

The effect of excessive quantities of very stimulating nitrogenous manure on the production of sugar was noticed by Lawes and Gilbert, in their experiments on sugar beet (*vide* Jour. Roy. Agri. Soc., Eng., series iii, Vol. IX, Pt. ii, 1898, pp. 344-370). The most liberal manuring was followed by the growth of the heaviest crops, but the production of good roots was coincident with more moderate applications of manure. As in our Indian field experiments with sugarcane, so here, the quantities of manure were in some cases far greater than was supposed to be necessary ; such for example was an application of 14 tons of farm-yard manure plus 2,000 lbs. of rape cake and 400 lbs. of ammonia salts. On the other hand 14 tons of farm manure alone, or 2,000 lbs. of rape cake used in conjunction with some superphosphate, or 400 lbs. ammonia salts plus superphosphate, all produced roots of excellent quality.

The whole evidence on the subject rather points to the comparatively slowly decomposing manures as the best for the production of cane-sugar whether obtained from sugarcane or from beet. In the Manjri experiments farm-yard manure and the oil-cakes stand out as being especially satisfactory, whereas sewage in excessive quantity is the least so, and at Cawnpore, poudrette—a very forcing material—when used in large quantity was distinctly disappointing.

The foregoing resumé of the experiments which have been made at farms in India, on the manuring of land for the sugarcane crop, may possibly leave the impression, that the chief lesson to be learned from them is to avoid excessive quantities of manure when cultivating this crop. But a danger lies in going to the other extreme, for it is unquestionably a crop which repays liberal treatment. Stubbs, in his book entitled "Sugarcane," suggests that manure containing 50 lbs. of nitrogen per acre is excessive. Certainly in India this recommendation would not hold good. For example, at Cawnpore, applications of 7 and 14 tons of farm-yard manure (containing about 70 and 140 lbs. of nitrogen) per acre on two plots resulted in only small crops.

Again, there is a belief among some people that heavy manuring produces poor juice. Examples have been quoted showing that this may occur. But the conditions associated with the occurrence must be carefully noted,

namely, very heavy manuring, resulting in an immature crop. It is the extremes that should be avoided.

In this article the quantities of manure which were employed in the experiments, have not been always mentioned, because it is necessary to compare the manures on the basis of their fertilising constituents, rather than on their gross weight. At the same time the agriculturist is naturally desirous to possess some simple guide as to how much of these materials should be used per acre. It has been sufficiently explained that since they vary much in composition, it becomes impossible to say precisely what weight of one is equivalent to another. Every farmer knows that one lot of farm-yard manure, or of poudrette, will be appreciably better than another, and this is the case with other materials. It pays indeed to employ a chemist to determine the quality of manures, for economies can thereby be effected, which are otherwise impossible. If, then, weights of manure are here suggested, their limitation must be recognised, and the fact that they depend on the materials possessing an average composition must be carefully borne in mind. Subject to this reservation the following may be recommended :—

	Per acre.
Farm-yard manure	20 to 30 tons.
Poudrette--in alluvium	15 to 20 ,,
,, in coarser soils	20 to 30 ,,
Fish manure	1 to 1½ ,,
Safflower cake	1 to 2 ,,
Castor ,, ...	2 to 4 ,,
Karanj ,, ...	3 to 5 ,,
Rape ,, ...	2 to 3 ,,

THE WILT DISEASE OF PIGEON PEA AND PEPPER.

By E. J. BUTLER, M.B., F.L.S.,

Cryptogamic Botanist to the Government of India.

THE PIGEON PEA WILT.

The pigeon pea (*Cajanus indicus*), known in Northern and Central India as arhar or tuer and in Bengal as rāhar, is one of the most extensively cultivated pulses in the country. There are, however, certain troubles encountered in its growth, and the study of one of these has disclosed a widespread disease of considerable interest which has hitherto escaped attention. It has been found to suffer habitually from a condition like that of flax (linseed) which is known as "flax sickness" in Europe and America, and which has thrown great difficulties in the way of successful flax cultivation in several countries. A similar disease has recently all but destroyed pepper cultivation in parts of the Wynaad in India, so that it has become necessary to ascertain the cause and to see what can be found out about the organism which produces these results.

Arhar is one of the crops which is ordinarily grown under rotation by cultivators. Apart from the ideas which are held—often vaguely—of the general advantages of this practice, very definite opinions have been expressed to me of the need of rotating this particular crop. I have, in fact, been told by cultivators that it cannot be grown with any success when sown year after year on the same field. This was borne out strongly by some experiments on the Kirkee Experimental Farm at Poona when the disease was under study in 1902-3. A large plot, affected by a moderate amount of disease in 1902, was re-planted with the same crop in 1903. The percentage of diseased plants rose enormously, and was well over fifty per cent. when I saw it in the autumn of 1903. On the Nagpur Experimental Farm also, the number of killed plants in 1902 was far greater on a field which had previously borne the same crop, than on one where it was planted for the first time.

These experiences are exactly like those which have long been known in the cultivation of so dissimilar a crop as flax. After a few years, if

rotation be not practised, the produce deteriorates to such an extent that it soon ceases to be profitable. In Belgium, flax is usually grown with a long series of other crops between, and a nine years' interval between successive crops is said to be not uncommon. In Ireland it has become extremely unpopular with farmers in some places, owing to what has usually been considered its exhausting effects on the soil. In the United States, farmers say the land becomes "flax-sick" after some years. That there is no reason for the belief that flax is unusually exhausting has, however, recently been shown by Professor Snyder at the Minnesota Experiment Station in the United States, the draft on nitrogen being much less than that of Indian corn or mangels and about the same as oats, while as regards phosphoric acid and potash the requirements are less than those of a number of common crops, including the above. So also arhar is stated in Duthie and Fuller's "Field and Garden Crops of the N.-W. Provinces and Oudh" not to impoverish the soil, and Dr. Leather has kindly analysed the soil of a plot on the Nagpur Farm, where large numbers of plants were dying, and found a sufficiency of plant food available. Finally, the cause of flax sickness in the United States has been definitely ascertained within the last few years by Professor Bolley of the North Dakota Experiment Station to be due to a parasitic fungus developed in the soil, and an allied fungus is responsible for arhar sickness in India.

The disease is found over an immense extent of country; Bombay, the Central Provinces, the United Provinces and Behar being the areas most affected. It has been reported to me from the Punjab, but I have not seen specimens. In fact, with the exception of Madras where I have neither seen nor heard of it, one may assume that wherever the crop is extensively grown, the disease is to be found.

The sequence of events in ordinary cases is somewhat as follows. A crop, which has germinated well, will begin to show withered plants here and there when the seedlings are a few inches high. As single plants are generally attacked at this stage they easily escape notice. Other plants near those first affected gradually dry up. When a period of hot dry weather occurs during the rains, large patches of withered plants appear with startling rapidity. These are composed of individuals in which the fungus invasion has not proceeded very far, but which are sufficiently affected to be unable to withstand the sudden strain thrown on the roots by hot and dry weather succeeding rain. As the plants approach maturity the steady progress of the fungus in the soil from the first diseased plants makes itself apparent by the ever-widening areas of disease. Arhar will grow for a second year if not interfered with, or if partially cut back, and in such

PLATE I.

Pigeon Pea Wilt.

"ratooned" fields sufficient time is given for so great an extension of the fungus that almost all the plants may be killed. Plate I shows part of a plot in my experimental field damaged by frost early this year and cut back so as to give a second crop. The part shown in the photograph is being invaded from every side, and the whole will probably be destroyed in another month or two. Almost the same effect is produced by sowing fresh seed on land which has had a diseased crop the previous year, and in two or three years of such treatment the condition obtained on the plot at Kirkee, mentioned above, is arrived at.

A closer examination of a plant which is partially dried up shows that some of the twigs may be quite dead, while others are still green and healthy. The dead shoots are not scattered promiscuously throughout the plant, but usually bear a definite relation to some portion of the stem; and on peeling off the bark it will be found that blackish streaks in the wood extend up from the base of the plant to the dead branches. On tracing the streaks down they will be seen to terminate in one or more blackened dead roots (Plate II, fig. 1). At a later stage other roots become affected, and the blackening extends over the greater part of the base of the stem. When the whole is involved, the plant entirely withers and remains standing with the dried leaves still attached to the branches.

The blackened portions of the base of the stem and roots contain quantities of the fungus in the bark and wood. At a late stage it may be found as high as two, three or more feet from the ground. It lies in coiled masses in the water-carrying vessels of the wood, and single threads run through the cells in all directions. It is one of those fungi which possess the power of boring through the cell-walls, to reach the living food supplies contained within the plant cells. But its most favoured situation is in the vessels through which water and food are conveyed to the leaves, and along these it extends with great rapidity (Plate II, fig. 3).

It can easily be induced to grow outside the plant, so as to permit of more definite study. Its reproductive bodies or "spores" can be sown like seeds in water or other substances, and on germination give rise to the fungus plants. Or by simply cutting out a part of the wood with precautions to avoid accidental contamination, a growth of the fungus can be obtained on its surface in moist air. Thus examined, the fungus has always proved to be the same, and in hundreds of cases seen it has never been absent. From its constant presence in the diseased tissues and from its evidently parasitic character, the presumption is strong that it is the cause of the disease. The proof is obtained by inoculating healthy plants with it and thereby giving rise to the disease.

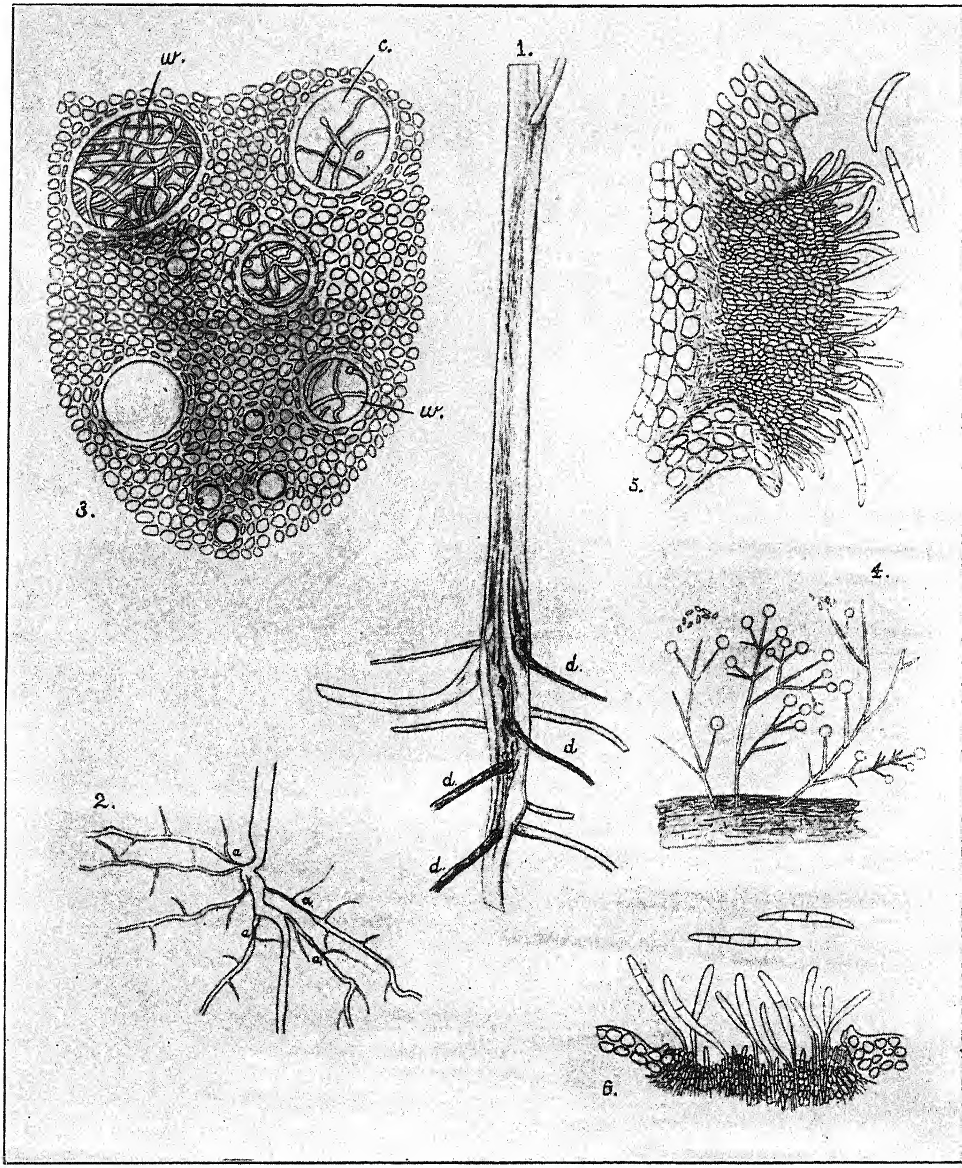
In the several series of inoculations carried out, the results have not always been the same. On one occasion seven out of thirty-one seedlings inoculated took the disease, and this is the best result obtained up to the present. In another case only eight out of one hundred succeeded, while in two or three series all failed. Though the successful cases leave no doubt that the fungus produces the disease, the uncertain results show that all the conditions which lead to attack are not known. There may be a variation in the virulence of the parasite, or different individuals of the arhar may be able to withstand its attacks to different degrees. Indeed, that something of the sort must be the case is clear when one realises the extraordinarily copious spore-production which this fungus possesses, and how commonly soil contamination must occur. Were all plants alike equally susceptible, and the fungus always equally virulent, the crop would be exterminated eventually in many places.

The formation of spores takes place after the fungus has developed luxuriantly within the tissues of the plant, and has appropriated for its own use, not only the living plant substance, but also, probably, the food supplies travelling in the vessels occupied by its threads. A brick-red efflorescence then appears on the surface of the bark, overlying the blackened streaks in the wood, and is composed of myriads of tiny spores which easily separate off and fall into the soil, or are carried about by the wind. But these, though far the commonest, are not the only sort of spore which is produced by the parasite, for no less than four have been found, representing so many different forms of its development.

One of these spore forms is more highly developed than the rest. It appears as round bodies of a bright red colour, smaller than a pin's head, scattered on the surface of the bark, generally near the base of the stem (Plate III, fig. 2). These indicate that the fungus is a *Nectria*, one of a group of fungi responsible for a number of wilt diseases of plants and cankers of trees. Within the red balls are numerous little spores arranged in groups of eight in thin sacks (Plate III, figs. 4 and 5). This form of spore is far from common, and is not at all a necessary part of the life of the fungus, for the others may go on reproducing it apparently indefinitely.

On sowing one of these *Nectria* spores in a drop of water, germination takes place by the growth of one or two long transparent threads, which branch and produce a little fungus plant. On some of the branches the second type of spore appears quite rapidly. This is smaller than the first, and several are produced in a globule of water at the tip of the branch giving rise to a form known as *Cephalosporium* (Plate II, fig. 4). A little later a third form is found; it is spindle-shaped and larger than the others. Though

PLATE II.



Pigeon Pea and Pepper Wilt Fungus.

in water cultures these arise singly from the tip of a free branch, on the bark they come out in cushions, formed of matted threads and bearing a fringe of spores all along the free surface (Plate II, fig. 5). It is this type (known as *Fusarium*) which produces the red layer on stems which have withered from the disease. Finally in old plants, or in cultures which are beginning to decay, the last form appears consisting of rounded thick-walled cells, well fitted to resist long exposure to unfavourable conditions.

Each of these forms can be produced at will from any of the others, with the exception of the first. This has never been obtained in artificial cultures in the case of the arhar fungus, and only once in the similar pepper parasite, though the attempts have been numerous and some have lasted over two years. The reverse, however, is easy, for all the stages can be obtained from the germination of the first. So we have the curious fact that in the life-history of this *Nectria* (as of several others) the highest development only rarely occurs in nature, and is very difficult to cause artificially ; while when once produced, all the other stages can be got from it with the greatest ease. And we may go on growing these other stages for a very long time without getting back to the perfect form.

The original infection of fields, which have not recently borne a diseased crop of arhar, takes place by spores either blown in by the wind or carried on seeds on whose surface they have fallen during harvesting. Bolley's experiments show that in the case of flax wilt the latter is a very common mode of infection. I do not think it often occurs with arhar, for few of my non-inoculated plants growing on fresh soil have been attacked when young. Its possibility, however, serves to explain the appearance of the disease in remote places, where the crop is not usually grown, and where seed is imported from a distance. Once a field becomes infected the majority of the plants subsequently diseased are attacked by extension through the soil. In this way the characteristic and ever-widening patches of disease are produced.

It is clear that no direct treatment can be successful against a disease of this type. The parasite early enters the internal tissues of the plant, and is then out of reach of any curative application. We possess, as yet, no means of destroying internal parasites without injuring the plants in which they live. Even iron sulphate, a substance which can be applied to the roots of plants in fairly large doses without ill-effects, and which possesses to some degree the power of killing fungi, has proved quite unavailing in this case.

There remain indirect methods of avoiding or resisting the attack, and two of these offer the chief hopes of diminishing the ravages of the disease. The first is the introduction of longer systems of rotation than are usually practised in arhar cultivation, wherever the disease is severe. No information

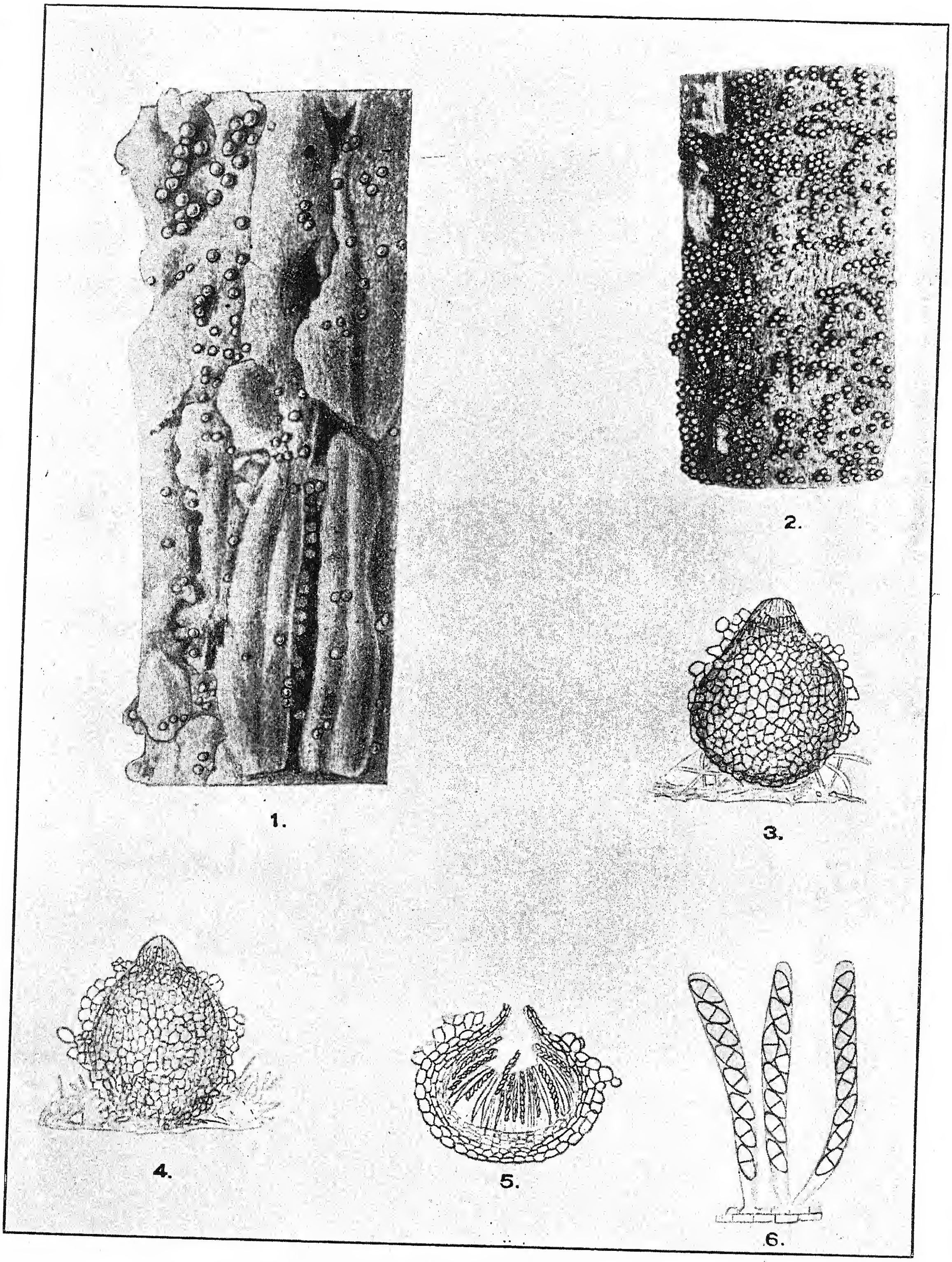
is as yet available regarding the length of time between successive crops required to cause the disappearance of the fungus from the soil ; three years is probably insufficient. Still, every year after the first, during which other crops are substituted for arhar, will diminish the amount of disease up to a period, the length of which we do not know, when it will entirely cease. It can, it is true, then be induced afresh by new infection from diseased seed or neighbouring fields, but the damage which can be caused in a single year by this means is so slight, that a sufficiently long period of rotation would probably, in itself, be enough to reduce the disease to insignificance. The other, and perhaps surer, method is to endeavour to find, or to produce, varieties which will resist the disease to a high degree. Unfortunately the varieties in cultivation are not numerous, a fact which DeCandolle remarks in the "Origin of Cultivated Plants" points to no very ancient cultivation. Several, however, do occur in India divided into two main groups, the "arhar" which has the upper petal of the flower veined with purple, and the "tuer" with the upper petal yellow. These have been sometimes separated into two distinct species known as *Cajanus bicolor* and *Cajanus flavus.* So far there is no indication that any of the common varieties resist the disease, but the collection of as many varieties as possible, in order to study their behaviour in regard to infection, has only just been commenced. There is some hope from the experience gained elsewhere that this line of work will give satisfactory results. One of the worst of the wilt diseases known, the cotton wilt, which is caused by an allied fungus, has been successfully checked in parts of the United States by the introduction into cultivation of wilt resisting cottons by the Department of Agriculture of that country.

THE PEPPER VINE WILT.

About 1900, a disease in some of the pepper estates under European control, in the Wynaad District of Malabar, began to attract attention. Its origin is obscure, but there is an abandoned plantation near Vayitri which is said to have died out from some unknown cause eight or ten years ago, and this may have been one of the earliest cases.

When I visited Wynaad in October, 1904, I found the alarm was general, for some estates had already lost the greater part of their plants and others were affected more or less severely. The disease was very virulent, and had succeeded in producing a vast amount of damage in three or four years. Its possibilities in this direction are evident from the fact that over four thousand acres of pepper cultivation are in the hands of Europeans in South Wynaad, and perhaps five times as many are grown by natives. A far greater amount is grown in the coast districts of Malabar, but it is impossible to estimate how much this may be.

PLATE III.



Nectria of Arhar and Pepper Wilt.

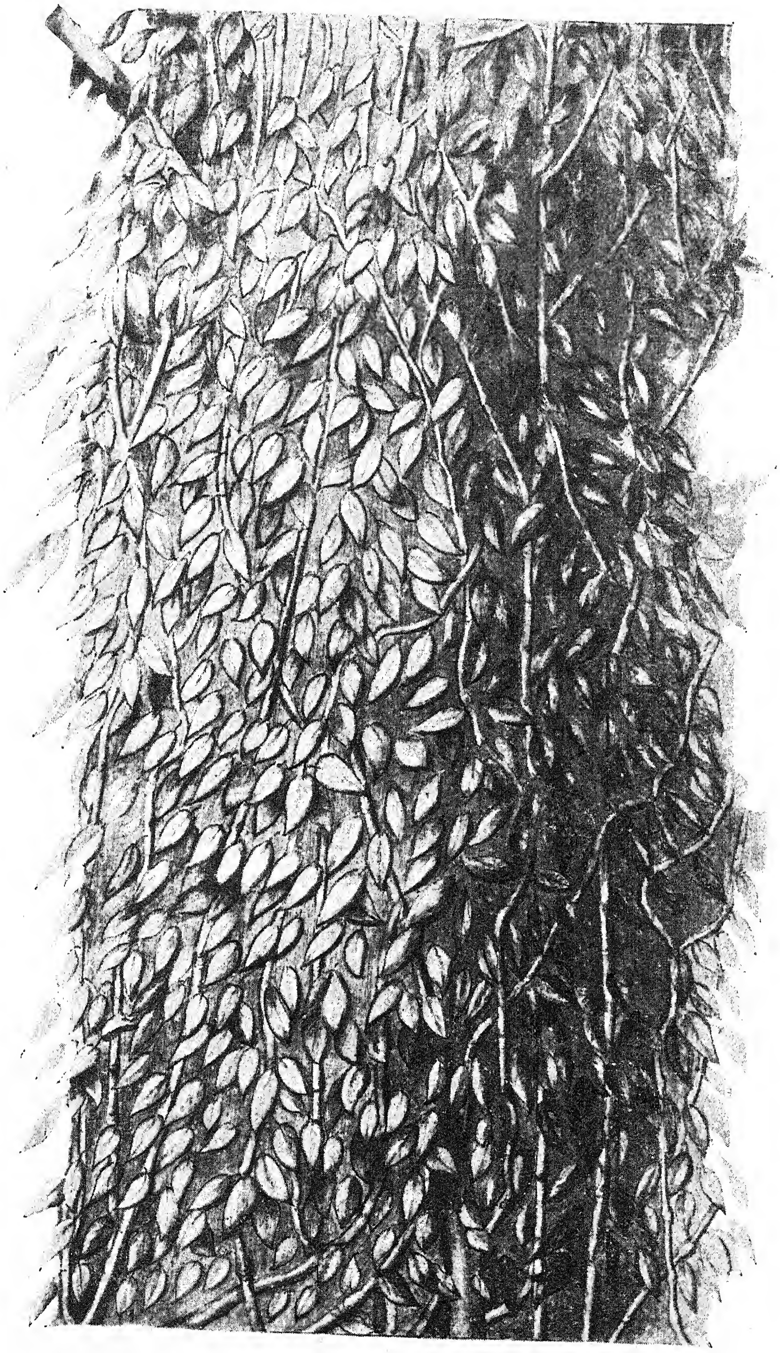
The black pepper vine (*Piper nigrum*) is grown in Malabar, as elsewhere, on living trees which are known as the standards. These may be either ordinary jungle trees or may be specially planted for the purpose. In the low country, palms are much employed, most villages having vines on a proportion of the palms which usually surround the houses. In the Wynaad Hills jungle trees are mostly used. The nature of the standard does not, so far as was observed, exercise any influence on the disease. In the coast plains dead or dying vines are not infrequent, though such wholesale destruction as occurs in the hills was not seen. Propagation is by cuttings, and the hill plantations were supplied with their seed cuttings from the plains ; the abrupt transition to a different climate may have had some effect in weakening the vitality of the plants.

In a healthy full-grown vine the trunk of the standard is entirely hidden in a mass of foliage (Plate IV). This arises from a number of climbing stems which closely embrace the standard and secure themselves to it by numerous tufts of aërial lateral roots. When such a vine becomes diseased, the first symptom noticed is an appearance which was described to me as a 'staring' look about the vine. This is due to a loss of rigidity in the leaves and leaf stalks, resulting in their drooping. With the collapse of the leaves the dense covering of foliage becomes diminished, and the stalks of the vine and patches of the trunk of the standard come into view. The next noticeable thing is that a portion of the climbing stems fall away from the standard, as a result of the death of the clinging roots and consequent relaxation of their grip. Soon the leaves begin to turn yellow, and numbers of them are shed. Later all the vine withers, and the standard remains lightly festooned with dead, relaxed stalks bearing a few dried leaves, as shown in Plate V. While the upper part of the vine makes no attempt at recovery, the lower part often retains sufficient vitality to form new leaves, or even to throw out fresh shoots. But these in their turn succumb, and I have not come across any case of recovery once the leaf-dropping has commenced.

A disease with exactly these symptoms is known on pepper in Cochin China and Java, and appears to have attracted attention at about the same time as that in India. In the Java Journal "Teysmannia" two articles on it have been written by Professor W. Zimmermann and Dr. Van Breda de Haan. Both ascribe its origin to the little parasitic worm *Heterodera radicicola*, the common root eelworm. In the second of these papers a very full account is given of its suggested mode of action, and Dr. de Haan considers that it does not directly cause the death of the vines, but opens a way to other rotting organisms such as bacteria. Mr. Barber, Government Botanist, Madras, who studied the Wynaad disease in 1903, also considered

that this worm was concerned, but did not assign to it the same degree of importance as the Java scientists, for he held that several causes contributed to the death of the vines, sometimes one being more prominent than another. That *Heterodera* is capable of killing plants is well known. But it is fairly common on the roots of cultivated plants, sometimes invading plant houses, conservatories and the like to such an extent that a large proportion of the plants may be affected. It does not, by itself, often cause death in these cases, and I think with Dr. de Haan that in most instances it merely weakens the root system, by exposing it to the attacks of other organisms. It is common, but by no means always present, on the roots of dead and dying pepper vines, and if it is to be considered the active cause of disease, can only be so in a certain proportion of cases. Certainly, as both Dr. de Haan and Mr. Barber point out, the pepper plant is less able to meet its attacks than many others. It is largely a surface feeder, and the roots tend to become collected in the mound which is usually, in the Wynaad, built up round the base of the stem. Once the parasite becomes established here, it meets with ideal conditions for its multiplication. The larvæ have only a short way to travel to meet with fresh roots, and the whole of the mound rapidly becomes infested. Moreover, the power which plants possess of healing wounds by the formation of protective tissues at the damaged part is shared in by pepper only to a limited extent. A morbid process is easily induced by any injury, resulting in the growth of large galls and cankers composed of tissues which break down and decompose readily. These tumours are common on the roots of cultivated vines and are one of the most remarkable features of their structure. They are often associated with the attacks of *Heterodera*, but not always, for they may develop above ground in parts which the worm cannot reach. Another circumstance which places the pepper vine at a disadvantage is the fact that it does not appear able easily to form new roots to replace the old. These marks of weakened vitality are probably to be traced, in part at least, to the practice of propagating always by cuttings. It is well known that plants reproduced in this manner, or from tubers or grafts, show less power of resisting disease than when grown from seed. And it is easy to see that when vines of lowered vitality become severely attacked by *Heterodera*, any sudden or severe strain, such as is induced by an unfavourable season, may cause death. But the uniformity of symptoms in the Wynaad disease, and the fact that the vines in some estates have been destroyed almost without an exception, altogether independently of the degree of *Heterodera* infection or canker, shows, I think, that we must look further for the primary cause of the disease. This I believe I have found in a parasitic *Nectria* fungus, similar to that described above.

PLATE IV.



Healthy Pepper Vine.

A J 1

The wilt-producing fungi of this group are often difficult of detection. The cause of flax sickness, for instance, escaped notice for many years. This is due to their existence chiefly in the imperfect state, which is similar to that of several common soil fungi, and to the rare production of the characteristic red perfect form. The pepper wilt is an exception in this respect, for at certain times of the year the red spore-cases appear in large numbers on the bark of the dead vines. I was fortunate enough to visit Wynaad at a time when this form was appearing in full vigour, and it was found on a considerable proportion of wilted plants. In every dead or dying plant examined the internal form was found, and in many cases the little *Cephalosporium* spores were observed on the threads in the vessels. Externally both *Cephalosporium* and *Fusarium* forms were always produced on the bark, though in much smaller degree than in the case of the arhar wilt. Cultures of all these forms were obtained for study and their connection established. From the *Nectria* spores all the other three spore-forms described above under the arhar wilt were produced, and in one case the *Nectria* was obtained from some *Cephalosporium* spores formed on the bark. In all the stages the fungus proved to be indistinguishable from that of the arhar wilt.

A careful examination of the roots of diseased vines disclosed the same pathological conditions as are found in other wilt diseases caused by fungi of this group. Where *Heterodera* was absent, or found only in insignificant quantity, the resemblance was close. Certain roots only rot in the earlier stages. These are blackened, and the blackening extends into the base of the stem. But the cause of the rot is much less sharply defined than in the arhar disease, for the pepper vine has the misfortune to possess very delicate tissues which are rapidly killed and become a swarming mass of putrefying organisms. However, here also, extension of the fungus occurs much more rapidly through the vessels than elsewhere, and the fungus web may be obtained in parts which lie outside the rotting tissues, causing, as usual, blackened streaks outlining the portion of the vascular system infected. At the same time an abundant formation of gum or oil takes place, and the cavities even of uninfected vessels are loaded with this, so that the circulation of water is much obstructed.

The fungus must under these conditions be carefully distinguished from another, which is found sometimes in vines apparently in perfect health. The latter runs in long transparent threads through the vessels of every part of the plant, but produces no symptoms whatever and does not tend to choke the vessels by branching into a web. Vines containing quantities of this fungus have been kept under observation for more than a year, and

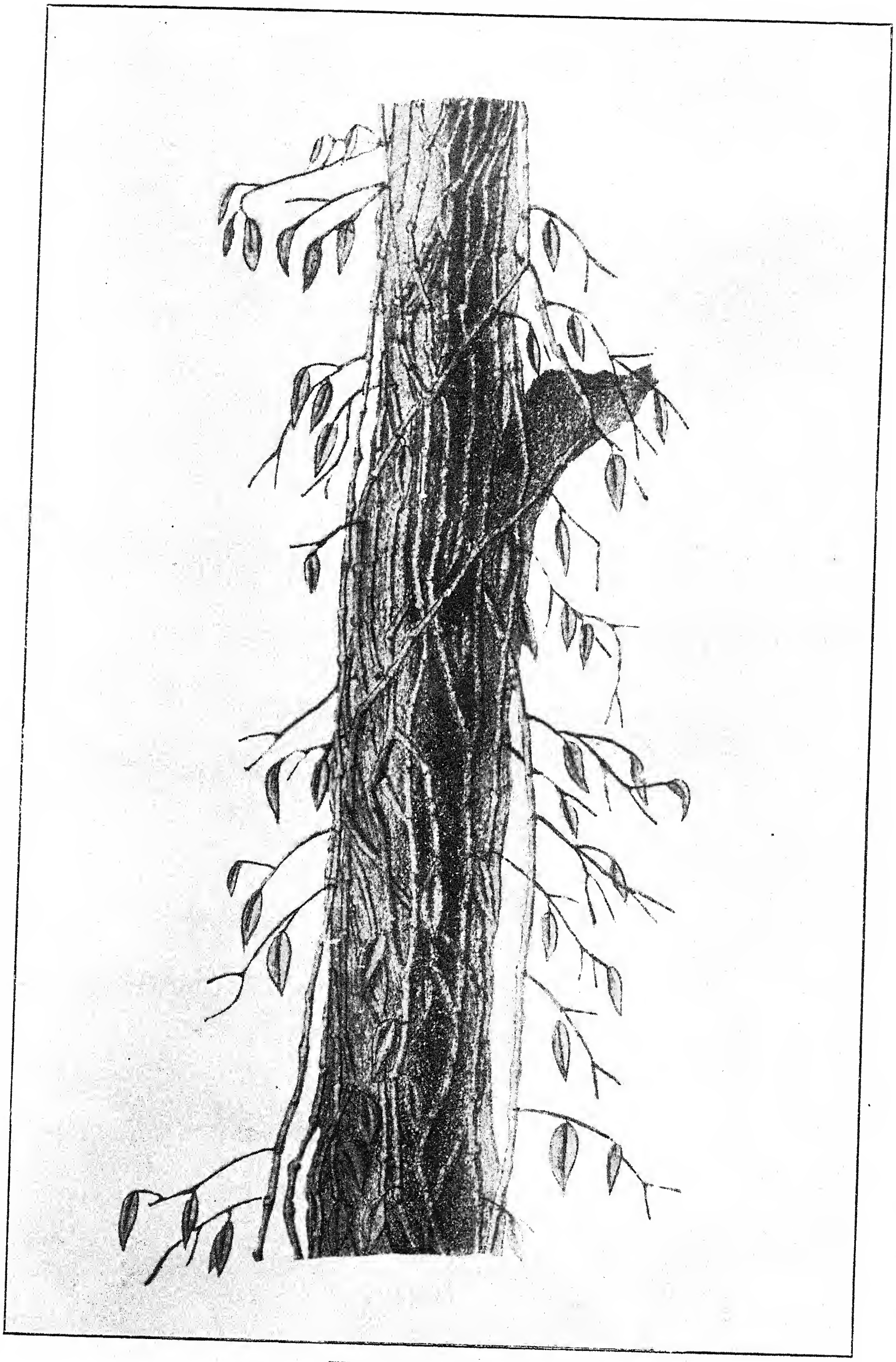
have developed no signs of disease. There is not the same excessive production of gum as above mentioned, and the flow of water is apparently not interfered with.

All the symptoms of the disease point most definitely to an obstruction of the water-supply from below. In most plants a partial destruction of the roots is followed by withering of the top, while the lower branches may remain green for a time. The diminished water is apparently all appropriated by the latter. In the pepper disease this is also the case, for the top usually is the first to suffer. In arhar, on the other hand, one or two branches towards the base usually die first, and dissection shows that the vessels of these branches arise from one or more dead roots. Here there appears to be a definite connection between individual roots and corresponding branches, which is not evident in pepper. This is the only distinction between the two diseases and, as I have said, probably depends on anatomical structure.

In affected estates it can often be observed that the symptoms develop very differently according to the time of the year and the conditions under which the vines are growing. The disease becomes more intense during breaks in the rains and immediately after the monsoon. Exposed vines also go out more rapidly than those which are well shaded. The reasons for this are simple. In moist weather or under dense shade, transpiration, or the giving off of water vapour from the leaves, is feeble, and the amount of water required from the soil is small. In these conditions the root disease may remain quiescent for a considerable time. But when warm, dry weather follows, the quantity of water given out is greatly increased especially in imperfectly shaded localities, and the vines wilt rapidly. In the same way good cultivation, or anything tending to increase the root development, or to retain the soil moisture near the surface, checks the rapidity of the attack. But I do not believe that favourable seasons or good cultivation can be expected to exercise more than a temporary effect, for once the fungus becomes established, there is nothing to show that it is ever shaken off.

To sum up, we have a disease resembling in its characters the wilt disease of arhar and clearly associated with interference with the proper functions of the roots. Attacking the latter we have two parasites, the eelworm *Heterodera radicicola* and the *Nectria* fungus. The former produces galls and cankers which lead to rotting of a portion of the roots, sufficient in bad cases to cause withering when the vines are exposed to unfavourable conditions, such as drought. But it is present in large numbers only on a certain proportion of diseased vines, and may be quite rare on some

PLATE V.



Wilted Pepper Vine.

A J I

which have nevertheless died with characteristic symptoms. The latter—the *Nectria* fungus—was found on every diseased vine examined. It is botanically identical with the fungus which we know from inoculations to be the cause of the arhar wilt, and the vines die in a manner closely resembling the latter. Therefore, though not demonstrated by inoculation it is, I think, sufficiently established for practical purposes that it is the primary cause of the disease. It is, as one planter expressed it, "a known bad character found loitering," and the results bear a close resemblance to its handiwork elsewhere. And as such we are justified in charging it with the crime.

In considering what can be done to deal with this unfortunate state of affairs in a once most promising industry, the same general principles must guide us as hold good for the arhar wilt. Direct treatment is little likely to be successful. Rotation is, of course, out of the question with a perennial plant like pepper, and it seems that the only chance lies in the introduction of fresh varieties into cultivation. Unlike arhar, a considerable number of varieties of pepper occur in South-East India. I came across at least four, distinguished by vernacular names in the Wynaad. Others are probably cultivated in Kanara, Mysore and the Malabar plains. Wild varieties are met with in the jungles. Thus the materials with which a start can be made are more promising than in the case of arhar. But the work must be far more tedious where the plant under study is a slow-growing perennial than with an annual, and results cannot be expected for a long time to come. The disease itself also requires much more extended study than it has received. Both these objects have been provided for in a recent step taken by the Madras Government. An experimental pepper farm has been founded at Taliperamba in Malabar intended for the study of the different varieties of pepper and for the investigation of the disease. It is not too much to say that the resuscitation of a threatened industry is largely bound up in the results which may be obtained at this farm.

A few words may be added concerning other diseases of a similar nature caused by this class of parasitic fungi in India. In none but those above described has the perfect form of the parasite been met with, so that their identity is doubtful. But in all, excepting gram, the *Fusarium* and *Cephalosporium* forms have been found, and the effects on the plant are similar in their main outlines. The most important from the economic point of view is the cotton wilt, reported from the Punjab in the last two years. The disease spread to bhindi (*Hibiscus esculentus*) at the Lyallpur farm in 1905, and as this plant is also attacked by the fungus producing the cotton wilt disease of the United States, there is much reason to fear that the two diseases are identical. Fortunately, I think that it is not widely distributed

in this country, for I have not met with it elsewhere ; and unless it should happen to have been introduced recently, this fact rather indicates that conditions are not favourable for its spread in India. Deccan hemp (*Hibiscus cannabinus*) was attacked by a similar disease in the Calcutta Botanic Gardens in 1904 and a number of plants were killed. Wilts of fennel (*Fœniculum vulgare*) and soy bean (*Glycine Soja*) were found in Coimbatore District (Madras Presidency) in the same year, the former especially causing considerable damage, for the crop is a common one in homestead lands, and a number of the fields seen bore large patches of withered plants. Gram is said to be severely affected in Bombay, if often resown on the same land, but in the specimens which I have examined a *Cephalosporium* fungus alone was found. It appears probable that these diseases are more common than is usually thought, for though the only other country which has reported a considerable number is the United States, this is probably due to the difficulty often experienced in detecting the parasite. The evidence available from the United States, where nearly twenty different species of plants are affected, and India, where seven or eight have already been found, seems to show that there exists a large homogeneous group of diseases induced by closely related parasitic soil fungi, and the study of any one of these may be expected to throw light on the others.

EXPLANATION OF THE PLATES.

PLATE I.—Portion of a ratooned diseased crop of arhar where the healthy plants are being rapidly invaded from all sides. From a photograph.

PLATE II, FIG. 1.—Stem of a diseased plant of arhar in the early stages showing the blackened streaks leading from the affected roots *a* to a withered branch *b*. Fig. 2—Roots of a wilted arhar seedling showing parts of several roots attacked at *a*, *a*. Fig. 3.—A portion of the wood of a wilted arhar plant showing the water ducts *w* occupied by fungus threads. In *c* a couple of Cephalosporium spores have been produced within the vessel. Fig. 4—Cephalosporium form of the pepper wilt fungus. Fig. 5—Fusarium form of the arhar fungus. Fig. 6—Fusarium of the pepper fungus.

PLATE III, FIG. 1.—Nectria form of the pepper wilt fungus magnified six times. Fig. 2—Nectria form of the arhar wilt fungus magnified three times. Fig. 3—Spore case (Perithecium) of the arhar fungus more highly magnified. Fig. 4—Spore case (Perithecium) of the pepper fungus. Fig. 5,—Spore case of the pepper fungus cut across showing the little sacks containing spores. Fig. 6—Some of the spore sacks more highly magnified.

PLATE IV.—Healthy pepper vine thickly clothing the trunk of its standard. Drawn from a photograph.

PLATE V.—Wilted pepper vine in the same estate drawn from a photograph.

CONDITIONS DETERMINING THE AREA SOWN WITH COTTON IN THE UNITED PROVINCES.

BY W. H. MORELAND, B.A., C.I.E., I.C.S.,

Director of Land Records and Agriculture, United Provinces.

IN years when local supplies of cotton fall short of the demand, I am frequently asked by merchants and manufacturers why larger parts of the provinces do not grow cotton, and why the cotton-growing tracts do not put down a larger area. The answers to both questions are of some interest not only to those engaged in the cotton industry, but to students of the agriculture of the provinces. I propose to examine them in the light of the statistics which are available since 1860.

A word of explanation is necessary as to the meaning of the area figures used in this note. In the old returns the area recorded as sown with cotton is the sum of the areas of all fields on which cotton was grown, either as a sole crop or mixed with other staples. For some years past, however, the published figures attempt to deduct the area occupied by other crops mixed with cotton: thus, if 20 acres are reported to be sown with cotton mixed with *arhar*, only 16 acres will be shown in the returns as sown with cotton, the remaining four acres being entered under *arhar*. Opinions differ as to the advantages of this procedure, but the question need not be discussed here it is sufficient to point out that materials do not exist which would render possible a reduction of the older figures to the newer system, so that it is necessary to adhere to the older system throughout, in order that the figures given may be comparable. All the area figures given in this paper represent, therefore, the total area of the fields on which cotton was sown, whether as a pure or as a mixed crop. It may be added that the figures given take no account of the small area sown with cotton in Oudh, as statistics for the Oudh districts are not available for the earlier portion of the period under review.

The distribution of the cotton area in the provinces can be seen from this table :—

TABLE I.

Distribution of the Cotton area in the Province of Agra.

Tract.	Percentage of total area sown in			
	1865.	1870.	1900.	1904.
Meerut and Agra divisions	45	50	58	67
Allahabad division	35	33	30	23
Total cotton tracts	80	83	88	90
Rohilkhand	16	14	11	9
Rest of province	4	3	1	1
Total non-cotton tracts	20	17	12	10

There are two well-defined cotton tracts, the upper and middle *duab*, containing the Agra and Meerut divisions, and the Allahabad division which includes both the lower *duab* and the country south of the Jumna known as Bundelkhand. The table shows that the percentage of the whole cotton area which lies in the cotton tracts has risen during the period under consideration from 80 to 90 ; the proportion is really perhaps slightly higher, as in 1904 (the last year given in the table) there were special hindrances to sowing in Bundelkhand. It will be seen then that the tendency is to confine the cotton area within certain tracts. This tendency is seen in the case of some other crops also, notably sugarcane, and it finds a ready explanation in the development of trade and communications which has been so marked during the period under review. At its commencement railways were rare and trade was still carried mostly on the rivers, while large areas were landlocked. Cotton was then grown to a small extent all over the country for consumption in the villages, even when local conditions were unfavourable to the crop : this still occurs, but more and more people whose climate or soil is not well adapted to cotton are taking to purchase the supplies which they need, and which the railways bring within their reach. There is every reason to suppose that this process of concentration will continue, and that the production in the submontane and eastern districts, already trifling, will still further diminish. It appears to be possible that if prices are maintained at a certain level, the cotton-tract may extend some distance northward across the Ganges, that is in south Rohilkhand and in a portion of south Oudh ; but no increased production can be expected in the future from the bulk of the area classed in Table I as non-cotton tracts,

unless the level of prices should be permanently raised by a substantial amount.

Apart from the conditions of soil and climate, there is an artificial factor that tends to confine the growth of cotton to certain definite tracts. It is generally recognised that the shortness of the growing season is a serious handicap to cotton growers in these provinces: this evil can be met to some extent by sowing with irrigation before the rains break, a practice that has other advantages also, for if the plants get a good start they may escape injury from the heavy rain that is usually received in July, while the prolongation of the tillage season, enables the cultivator to do greater justice to all his land alike. But the irrigation must come from canals; lifting water from wells in May and June is ruinous to the cattle employed, and the rapidity of evaporation makes the practice unprofitable, if not impracticable, in all ordinary cases. Now, the *duab*, the chief cotton-tract, is very copiously provided with canal water, and here the practice of early sowing is spreading rapidly, while the recent reduction* in the water-rates charged on this crop, will undoubtedly accelerate this most desirable development in agricultural practice. In the other cotton-tract, Bundelkhand, canal water is not yet available in the sowing season, but it is hoped that the works now in progress will suffice to provide a supply in a few years' time, and then early sowing, and probably the total area, may be expected to increase. The canals thus give a differential advantage to the cotton-grower whose land lies within their scope, and this advantage must gradually tell on the distribution of the area.

The considerations that determine the area sown in the cotton-tracts in any year are, perhaps, more complex than those which govern the distribution of the crop over the provinces as a whole. The area is governed by the action of a very large number of individuals, not very well informed, and somewhat exposed to the influence of fashion and of prejudice. It is not, therefore, to be expected that every variation from year to year can be explained by facts on the official record. At the same time it is possible to state with some approach to precision, the main motives that govern the action of the individual cultivator, and even to measure by statistics the variations in weight of these motives in different years.

When a cultivator sets to work to plan out his autumn campaign, his first object is to provide enough food to carry his family and his labourers over to the next harvest, and perhaps a little beyond; therefore the area that he will devote to crops intended for the market, will depend mainly on the

* With effect from 1905 the water-rates on cotton have been reduced by one-third throughout the cotton-tract.—W. H. M.

stock of food within his reach at the time of sowing. Now, putting aside the special cases of individuals, it is fair to say that the condition of the mass of the cultivators in this respect can be generalised ; in some years they have much more food than others, so that a rough measure of the areas that will be devoted to crops for the market in any tract can be obtained from a record of the food-stocks available in the tract at sowing time. There is no more hopeless problem in Indian statistics than to determine actual food-stocks, but fortunately this is unnecessary for our present purpose : it is sufficient if we can discover an index to fluctuations in stocks, without reference to their actual amount, and such an index lies ready to hand in the price of wheat prevailing in local markets. It is well known that in Upper India the prices of all food-grains taken together follow the price of wheat, so that if price-curves are plotted, the shape of the wheat-curve is almost exactly similar to that of the curve for all other grains. It follows that the wheat-curve can safely be used, except, perhaps, in seasons of acute distress, as a guide to fluctuations in food-stocks.

But this is not the whole question. Having measured the motives that determine the area of crops for the market, we have still to measure those that govern the sowing of cotton rather than of some other market crop. There are of course large numbers of cultivators who will sow cotton in almost any circumstances, but the area they sow will depend to some extent on the return expected, while there are also large numbers who will sow cotton only if they think it will pay them better than other crops. Thus the main motive is measured not so much by the price of cotton as by the ratio between the price of cotton and that of other market crops. The ordinary cultivator is not able to look far ahead, and so far as we can discover he is guided largely by the prices prevailing at the time he is planning his campaign, that is, by the prices of the last preceding crop ; but he has a good memory, and the after-effects of a period of high profits or of losses can be observed for a long succession of years.

If then the sowing season itself were not liable to fluctuations, we might expect that it would be possible to trace a fairly close connection between the area sown and the ratio of cotton-prices to prices of other produce ; but unfortunately the question is complicated by accidents of season. It has been pointed out above that the growing season in these provinces is really too short for cotton ; if, therefore, anything happens to interfere with the sowing of cotton at the beginning of the season, the cultivator revises his plans and sows some crop that will succeed when sown later. This fact is very clearly established by a long series of statistics ; whenever the rains are late, or whenever they are so continuous at the start as to retard sowings, the

proportion of cotton to other autumn crops falls materially, so that it is always safe to estimate that if the rains are not established by the beginning of July, the cotton area will be lower than would otherwise be the case.

The evidence on which the foregoing remarks are based is summarised in the next table :—

TABLE II.

Area sown with cotton in the last 44 years, with ratios of cotton prices to wheat prices.

Year.	Ratio. of prices.	Area (thousands of acres).	Year.	Ratio. of prices.	Area (thousands of acres).
1861	79	953	1883	86	1,622
1862	127	986	1884	117	1,570
1863	417	1,136	1885	134	1,576
1864	333	1,740	1886	122	1,790
1865	92	895	1887	80	1,445
1866	128	1,103	1888	100	1,342
1867	93	947	1889	110	1,577
1868	...	865	1890	93	1,519
1869	107	1,152	1891	96	1,196
1870	159	1,248	1892	100	998
1871	148	1,072	1893	102	1,266
1872	109	1,266	1894	124	1,444
1873	85	980	1895	107	1,261
1874	122	1,092	1896	86	1,370
1875	172	1,056	1897	53	1,079
1876	191	1,186	1898	74	1,102
1877	123	718	1899	81	1,168
1878	122	1,316	1900	72	1,228
1879	86	1,240	1901	68	1,361
1880	126	1,378	1902	90	1,463
1881	127	1,594	1903	97	995
1882	96	1,642	1904	152	1,401

This table shows for the last forty-four years the area sown with cotton and the ratio which the price of an acre of cotton bore to an acre of wheat in the sowing season of each year ; the ratio is calculated by taking the market prices at Cawnpore of cotton and of wheat, and applying them to the "normal" outturn per acre, the term "normal" denoting the outturn that the cultivator expects to get and that influences his calculations. It will be seen that this ratio is calculated to measure the resultant of the two principal motives that influence the cultivator in regard to sowing cotton. If food-stocks are large, the price of wheat is low, and the ratio of cotton to wheat is high ; while if food-stocks are low, the price of wheat is high, and the ratio of cotton to wheat is low, even though cotton prices may themselves be higher. Similarly, if the price of wheat is high, the cultivator who has food on hand will be inclined to sow wheat or some other food-crop as a market crop, while if it is low, he will prefer cotton. In the table the ratio 100

denotes that an acre of cotton brings the same price as an acre of wheat; 150 means that an acre of cotton fetches $1\frac{1}{2}$ times the price of an acre of wheat, and so on.

The first five years dealt with in this table cover the "boom" and the "slump" connected with the Civil War in the United States. It will be observed that the area did not respond at once to the famine prices of 1863, but that in 1864 an enormous area was sown. Some district officers at the time took credit for the increased area in their districts; how far their action was really effective, is a matter that need not now be determined, but it is probable that most of the increase was due to the hope that the high prices had come to stay. This hope was disappointed, for that year's crop sold at prices which left no profit, and in 1865 the area fell by one-half.

It is difficult to speak with certainty about matters that occurred so long ago, but from conversations with men who remember the time, I have formed the idea that the effects of this "slump" on the imagination of the people was very great, and that the cotton crop became very unpopular for at least a decade. If we omit the year 1868, for which prices are not available, it will be seen that in the 24 years up to 1890 cotton was more valuable than wheat in 16 years, but that the area ruled low until 1876: at that time the ratio had been above 100 in eight of the ten years that had elapsed since the slump and below it in two only; in the eight years it had averaged 143 (or nearly three to two), and the average area sown in these years was 1,147,000 acres, while in the remaining two years the ratio averaged 89, and the area 9,63,000 acres. Thus, years of high ratio had higher areas than years of low ratio, in accordance with what might be expected, but the areas in high and low years alike, were less than the gradual development of the provinces gave reason to expect.

The year 1877 forms an abrupt break in the statistics; in some parts of the cotton tracts there were literally no rains at all, and no conclusion can be drawn from the area figures. After this year it appears that the unpopularity of the crop was giving way before the series of high ratios that had followed the slump, and in the decade from 1881 to 1890 the standard was about $1\frac{1}{2}$ million acres. In the thirteen years from 1878 to 1890, the ratio was above parity in seven; in these it averaged 122 and the area averaged 1,543,000 acres: while in six years the ratio averaged 90, and the area 1,468,000 acres. Here again the years of low ratio are years of comparatively low area, but the fact that the area in them was not still lower must be attributed to the renewed popularity of the crop. Over the whole thirteen years the average ratio was only just above parity, but the steady high prices of the previous decade had established the custom or fashion of sowing cotton.

At last, however, this popularity began to wane ; from 1887 to 1890 prices were unsatisfactory, and after the latter year, a marked drop in the area is apparent ; it was undoubtedly aided by unfavourable sowing seasons, as the rains were very late both in 1891 and 1892, but in 1893 with a favourable season the area was much lower than the experience of the eighties would have suggested. The years from 1891 to 1904 are, on the whole, a period of low ratios : the ratio was above 100 in only four, when it averaged 121, and the area averaged 1,343,000 acres : while it was 100 or less in ten, averaging 82, with an area averaging 1,196,000 acres.

Comparing the areas in the two sets of years of high ratios, it is seen that in the first a ratio of 122 brought out an annual area of over $1\frac{1}{2}$ million acres, while in the second a practically equal ratio (121) brought out 200,000 acres less : this difference is the measure of the cumulative effect of a series of years, of success in the first case and of failure in the second. The disparity between the two sets of years of low ratios is even more pronounced, but part of it is attributable to bad sowing seasons, as the rains have been late in the later period much more frequently than past experience would have suggested.

The table then seems to show that the area tends to fluctuate from year to year in accordance with the ratios of prices, but that the cumulative effect of a series of years of high or low ratios, is a most important factor in determining the absolute area, as distinct from the fluctuations. It is here that the motives which I have described as fashion and prejudice come into play.

It will be seen then that at the present time cotton has a good deal of prejudice to live down ; for nearly a decade the ratio has stayed below parity, and in 1904 when it rose to a point higher than for 19 years past, the area was roughly $\frac{1}{4}$ million acres below what the experience of the later eighties would have suggested. Whether the prejudice will last for a decade on this occasion remains to be seen ; there are grounds for hoping that the reduction of water-rates and the extension of the canal systems, will counteract the effects of the past range of low prices, and possibly the effects of custom may not last so long. But the fact remains that the experience of the last decade must act as a drag on expansion for many years to come.

THE SAMALKOTA SUGARCANE FARM.

By C. A. BARBER, M.A.,

Botanist to the Government of Madras.

In giving an account of the sugarcane work at Samalkota, it is advisable first to trace the origin of the farm. Upon the Government Botanist's arrival in the country in 1898, a serious disease of a somewhat obscure nature was found present in the fields. The number of acres under cane in the Godaveri Delta, one of the richest cane-growing areas in Madras, had greatly decreased, and the export trade of jaggery from the port of Cocanada had seriously declined and was threatened with extinction. Under these circumstances, the Government Botanist was early deputed to make an investigation of the disease. This was determined to be caused by a parasitic fungus, *Colletotrichum falcatum*, well known in Java and the West Indies.

During his inspection of the fields, he was led to form certain views regarding the spread of the disease at variance with those usually adopted, and as it was impossible to test the matter at issue in the ordinary ryots' cultivation, it was suggested that a few acres of land should be rented from the ryots and the disease studied on the spot. This proposal met with the approval of Government, and in April 1902, five acres of land were planted with sugarcane, and placed in the Government Botanist's charge.

The conclusions arrived at before the establishment of the farm were as follows :—

(1) That the disease was an *internal* one, in the sense that it passed from generation to generation inside the plant. The rarity of spore-formation and the extremely scattered nature of the small sugarcane gardens in the district, together with the slow but steady spread of the disease, appeared to discount the idea prevalent in the West Indies, that the disease was chiefly spread by the wind.

(2) That where the disease was spread from plant to plant, it was mainly through infected soil, or by the water channels into which the rotten canes were usually thrown.

(3) That the surest way to induce the disease to make its appearance was to plant the canes in a water-logged site. That no cane could withstand the disease when constantly submerged or kept in swampy ground, as was the custom of the ryot. That the ryot, in fact, had given way to careless cultivation because of his abundant water-supply, and had treated the sugar-cane in much the same way as he did paddy. Instead of incurring the labour of digging and aerating his land, he swamped it with water and worked it in puddle.

(4) It came to light, moreover, that it was no new thing for a favourite cane to be swept away by disease. Successive canes had held favour in the district during the past forty years, each in turn growing luxuriantly and bringing wealth, but after a few years becoming diseased and causing wide-spread loss. It was evident that bad cultivation was the cause of all this; the constitution of each cane had been broken in turn by the ever present fungus, until all the plants of that kind in the district were infected.

These beliefs have guided the work of the farm. The main object of the farm, was obviously to resuscitate this dying industry, and the various experiments which have been tried during the three years of its existence have had this point in view. Fresh land has been rented from the ryot year by year, and the canes have, therefore, been planted in strictly normal conditions (after paddy in puddle), but all matters of drainage have been attended to with the most zealous care. The most careful scrutiny of the sets planted has been maintained year by year, and all with the faintest visible trace of disease rejected. The result has been, that in the freshly planted land, disease has decreased each year in the canes, the farm always being the most healthy garden of the neighbourhood.

The first canes planted were such local varieties as could be got together, to which were added five varieties kindly contributed by Mr. Mollison from Bombay. In the second year of the farm's existence attention was drawn to the presence of a small field of canes at Vizianagram (about a hundred miles north of the farm), which had been introduced from Mauritius four years previously, and which had been allowed to run wild. These were carefully gone over, and such varieties as seemed to be of merit, were introduced into the farm. In the third year various canes were added from different parts of the country, including the *Kajli* and *Samsara* of Bengal.

The introduction of these new canes, and the collection, side by side with them, of the local indigenous varieties, resulted in the settled conviction that the whole of the local cane flora with its many varieties was permeated by disease, and that salvation was to be obtained by the discovery of immune

varieties. The improvement of the ryots' cultivation is a matter beyond the scope of a few years' agricultural experiments.

It is noteworthy that in the main varietal plots, whereas in the first year, nine local varieties were tested, these have now been reduced to three, all the rest having proved (generally speaking in their ratoon growth) that they were hopelessly diseased. The work on the farm is now largely carried on with varieties new to the district.

The two main lines of work have become, firstly, the selection of hardy varieties of good sugar content and the distribution of these to the ryot ; secondly, the discovery and even production of new forms to take the places of those already distributed and destroyed by the ryots' methods.

The farm was commenced under great difficulties. There were local troubles as regards labour during the first year and a half. There were no less than six changes of management in the same period. In each year the land had to be hastily acquired at a high rental and with insufficient time for preparation. On the other hand, the farm was extremely fortunate in the canes sent over by Mr. Mollison, for to one of these canes, as will be seen, it owes its present success. Its future power and usefulness is guaranteed by the unique case referred to above of that field of canes in Vizianagram, where some twenty kinds of Mauritius canes of good quality had been introduced four years previously, and allowed to fight it out under adverse conditions in a new country. Of the twenty canes introduced, about one-half have succumbed, two or three have practically monopolised the field, and sports and reversions have occurred abundantly.

It was noted early in the history of the farm that one of the varieties from Bombay, the *Red Mauritius,* showed good germinating power and healthy growth. It was analysed at the end of the first year and the juice was found to be fairly good. It is an axiom in cane-improvement, that no cane should be distributed from an experimental farm, until it has been thoroughly examined and tested for a number of years. But the matter was urgent, and the previous good character of the *Red Mauritius* in Bombay was allowed to have weight. Accordingly, at the end of the first year, sufficient sets to plant one-tenth acre plots were distributed to two ryots, under binding conditions that if so directed, they should boil the whole into jaggery. The power was thus retained of withdrawing the cane from circulation if desired.

During the second year the Red Mauritius sustained its character both in the plant canes and in the ratoons on the farm. At the end of the second year it was widely advertised both in the village sheet of the District Gazette and in the local papers, as well as by emissaries sent through the villages with samples of the canes. About eighty applications were received. In its

distribution it was sent to various parts of all the six taluks of the District. During the third year every one of the plots thus planted was twice inspected, the opportunity being taken for directing the ryots in their mode of cultivation. The result of this action was recently seen in widespread clamour for more seed. Hardly any *Red Mauritius* cane was made into jaggery, and far more applications were received than the farm could possibly satisfy, the seed changing hands in some cases at very high prices.

The first step towards the resuscitation of the industry has thus been successfully taken. A new cane, of good general character, has been placed before the ryot and he has eagerly taken it up. But this work of distribution has merely been commenced, and though certain ryots—and even villages, have declared that they will adopt the farm methods of cultivation, the great bulk of the ryots have as yet been in this respect untouched. There is hardly a village where the new cane cannot be obtained, but it is being subjected to the ruinous and wasteful water-logging of the district. How long its constitution will stand the strain is doubtful.

But meanwhile, other canes are being pushed forward on the farm to take its place. After reviewing the inspection results of the *Red Mauritius* plots referred to above, one ryot in each taluk was selected, because of their intelligent attempt at following the farm practice, and to them have been entrusted two more canes, the *White Mauritius* and the *Striped Mauritius*, for experimental trial during the year, under the same binding agreements. These six ryots will be visited during the year, and the result of the inspections will be made use of in the next year's distribution. It may be noted that the *Striped Mauritius* appears to be superior to the *Red Mauritius* in every respect except tillering power. It germinates well, grows to a great height, gives a heavy outturn, has very rich juice, and makes excellent jaggery.

Following this method, the farm is exerting itself more and more to produce a succession of good hardy canes. The *Ashy Mauritius* is probably slightly better than the *Striped Mauritius*, and all of them are apparently left behind by a new cane, a "sport" which has been analysed this year for the first time. These canes will have the advantage of a longer trial, and it is hoped that it will in time be possible, with certainty, to make a new cane available whenever it is desired. *Seedling canes* are not being neglected. Two varieties received from Barbados are now being acclimatised in an area apart from the farm. Fifty-two boxes of arrows have been put down during the last two years to obtain Indian seedlings. The results have not been satisfactory, as the fierce dry heat of the Coromandel Coast at the time of flowering, is probably too much for the delicate germ. Two seedlings were

obtained this year, but unfortunately succumbed after a few weeks' growth. It has been something, however, to determine that the ovary of the sugarcane is fertile in India.

Finally, an attempt is being made to raise resistant varieties of those canes which have gone under in the past. The principle of this is simple enough. Wherever in a patch of diseased canes, one or two healthy shoots are seen, these are marked, and later carried as seed to the "disease plot." Here the soil is purposely infected, rejected diseased cuttings are planted, and the plot is badly treated generally. The introduced stools mostly go under, but by repeating the process it is hoped that a more hardy strain may ultimately be obtained. The degenerate local kinds have some of them an excellent parentage, and there is no reason why, in time, success may not attend this mode of procedure.

Samalkota farm is purely local. It was started for the definite purpose of throwing fresh blood into the local cultivation. Incidentally, it will perform other functions. The ten best varieties have been sent down to South Arcot to form a new farm there, and the *Red Mauritius* and some other canes are already appearing in various parts of the country.

But, besides this question of distribution, advantage has been taken of its existence thoroughly to study cane cultivation and jaggery production from every point of view. The results of these enquiries cannot be dealt with in the present paper.

It has now been decided that the farm shall be made permanent, and thirty-six acres of land are being acquired for the purpose. This land, which is in a very rough condition, is being got into order, and permanent buildings are being erected. It may be possible on a future occasion to give some account of the various experiments being carried out on the farm.

THE INSECT PESTS OF COTTON IN INDIA.

By H. MAXWELL-LEFROY, M.A., F.Z.S., F.E.S.,

Entomologist to the Government of India.

The cotton plant, like all other crop plants, has its pests, insects which lessen the yield and quality of the lint and seed, insects which destroy the plant and very materially affect the gross yield from every acre. In the United States and Egypt these pests have been studied, and, especially in the States, vigorous measures have been adopted to check them. This has not yet been done in India; the results of investigation up to date are accordingly set forth in the following pages, with a view to drawing attention to these pests and to the best lines of experiment in checking them.

The annual value of cotton grown in India is stated to be in the neighbourhood of twenty million pounds sterling. The efforts that are now being made to improve the quality of the lint, to extend the area in cotton and to increase the yield per acre, are based upon improvements in the varieties grown, in the methods of cultivation and manuring, and in the quality of the seed. Less effort has been directed towards measures based upon checking the pests that now infest cotton throughout India, though it is probable that an improved quality of cotton, as well as a much larger yield, will be obtained when more attention is directed to this object. It is difficult to estimate the aggregate loss in the value of this crop from insect pests; the cotton grown in South Gujrat, Khandeish, and the Central Provinces is probably at least 10, and more nearly 20 per cent., below the yield that would be obtained were the plants free of pests; nor is this all, for the cotton that is picked is of poorer quality, and frequently stained by insect pests.

There is a further important point in which the work of insects has been hitherto neglected; many trials are being made of new varieties; exotic cottons are being introduced and acclimatised; hybrids are being produced; this work is done principally on experiment farms where insect pests are, from the nature of the farm, especially numerous. The results of these experiments and of these efforts at acclimatisation, are very seriously affected by insect pests, that is, by a factor that has up to now been somewhat neglected. It is

possible to find two plants of the same variety of cotton growing within a hundred yards, the one a fine vigorous plant yielding freely, the other a tall, straggling unhealthy bush that never yields and eventually dies ; this is often the work of insect pests, which seriously affects such experiments. The efforts made to introduce cotton into Behar in recent years have been very materially affected by the insect pests, and this is a factor that must be reckoned with if such attempts are to be a success.

The field study of cotton pests has not as yet extended into many cotton areas of India, but the enquiries have shown that the more important pests have a wide distribution in India, and in some cases in Ceylon and the Straits Settlements.

A total of sixteen insects are now known which are pests of cotton, but we may eliminate ten, as not seriously affecting the cotton crop. Every crop has minor and occasional pests which have to be watched, as they may at any time become important ; these need not concern us here, and we may consider only the really important species.

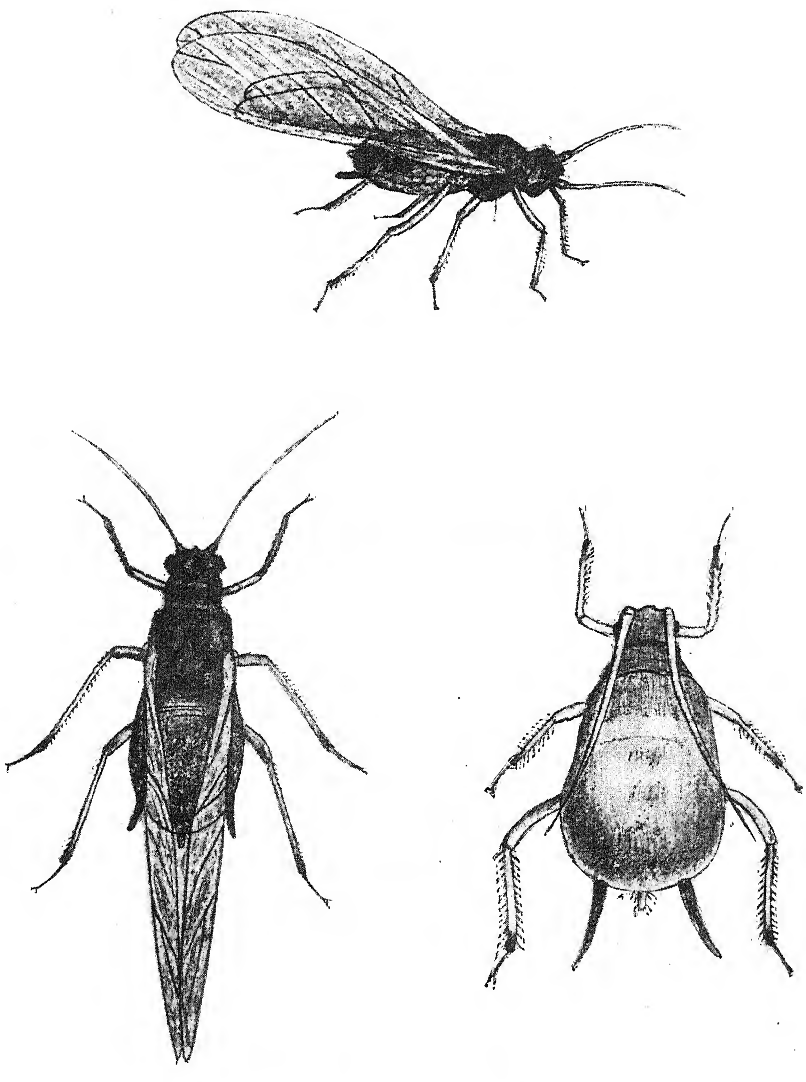
We may designate these pests by names similar to those in use elsewhere ; the cotton aphis differs in no essential from other aphides which attack crops throughout the world, and is clearly the equivalent of the same pest in cotton in the United States. So also are the bollworms ; in India there are three species of bollworm, which we may designate as the spotted bollworms, and (2) the pink bollworm ; these represent the notorious bollworm of the States which, though common in India, does not attack cotton. There is also the Red Cotton Bug, not the same species as the American Cotton Stainer, but similar in its effect on cotton. The cotton leaf caterpillar of the States is unknown in India, and that of Egypt is a species which in India attacks tobacco or other crops ; these are represented by an insect not of sufficient importance for inclusion here. Nor is the Texas boll weevil represented in India ; in its place we have the Stem Borer and the Stem Weevil, two pests whose importance is less than that of the notorious boll weevil, but which may still play an important part in cotton-growing in India.

THE COTTON APHIS. (*Plate VI.*)

Whatever be the species or the plant attacked, aphis is generally familiar ; multitudes of small dark insects, each no larger than a small seed, grouped in myriads on the leaf and stalk ; they move but little, generally remaining motionless, the beak buried in the tissues ; from each there drops a liquid which, falling on the leaves below, produces a shiny gummy layer ; in England they are known as green fly ; in India as *tela*, *mowha*, *mewa*, *mahu*, and the like. Looked at with a magnifying glass, one sees the legs,

PLATE VI.

COTTON APHIS.



A J I

the rounded body, the head with feelers, and, projecting from the hinder end, a pair of short straight syphons. Some are winged, some are wingless. There are many points of interest in their lives. In the warm climate of India, they are commonly viviparous, young being born alive and all females. Whether winged or wingless, the ordinary colony that multiplies so fast is composed wholly of females, producing young parthenogenetically at a rapid rate. The young is active and able to look after itself. In a few days it produces young and as all are females, the reproduction is amazingly large. When the colony is small and food plentiful, wingless females alone are produced; as the colony increases, winged ones are formed, ordinary young ones, which develop wings and presently fly off to a new plant to found a new colony. If all goes well, the small colony of to-day has in ten days covered several plants, and is daily spreading further over the field. The drain on the plants is very great and further growth becomes difficult. Instead of a healthy vigorous plant, we find a stunted growth unable to produce a full crop of good cotton. The net result is a small crop of poor cotton. But for natural checks on the pest, its increase during the favourable months would destroy the cotton; natural checks there are in the form of Ladybird beetles, lacewing flies, the syrphus flies and the aphis parasite. As the colony grows large, these come and feed upon the aphis. They breed among the colonies, and as they increase, so the aphis diminishes; it becomes a fight in which slowly but surely the enemies of the aphis win. Having devoured the aphis in one place, they move in search of fresh colonies. We cannot overestimate the beneficial effect of these useful insects, and we can only wonder that the aphis ever becomes a pest. But it does not always happen that the beneficial insects come in time or in sufficient number. In spite of its enemies the aphis often becomes a most serious pest, especially under certain conditions. The cultivator says that "Mahua" is a disease produced by cloudy weather; two causes appear to lie at the root of this fact; in cloudy weather the plant is apparently a more easy prey to the aphis, possibly because in the absence of sun the transpiration has become checked and the plant is turgid, possibly because the general vitality of the plant is simply lowered; also in damp and cloudy weather the aphis itself thrives; the winged aphis spread over the field and scatter; their enemies do not find them, and these flying individuals found colonies over a very large area; each colony separately does not afford food for the increase of the useful insects, and in a short time there are numberless small colonies, the progeny of these flying females. Very soon these become large and extensive, when the Ladybird beetles and other insects come. The aphis has by this time got so good a start that its rate

of increase is beyond the feeding capacity of the various enemies, and it is some time before the latter increase sufficiently to overtake the aphis. This struggle occurs frequently, circumstances sometimes favouring the aphis, at others increasing the numbers of the various insects that prey upon it. If we could assist these useful insects, or bring them upon the scene in time, nature alone would do the work, but we cannot at present assist nature in this respect. *(See Plate VII.)*

The significant factor is the healthy plant ; not only will a vigorous plant not succumb, but it will be less easily attacked. The moral is to grow only such cottons as are healthy enough to resist aphis. Most exotic cottons, and many Indian cottons growing in new localities, require to be acclimatised ; a cotton acclimatised to one district in India is not necessarily proof against aphis in the next district, and in seasons of unfavourable climatic conditions no cotton is immune. When new cottons are to be introduced, it should be done only where artificial remedies can be applied to check the aphis. There is but one sound artificial remedy, spraying, and this must be relied on to keep down the aphis that will otherwise attack exotic cottons that are not fully healthy. The time may come when the cultivator will buy and use a two-rupee sprayer, but that time has not yet arrived ; till then it is necessary to acclimatise the cotton by the free use of the sprayer; at present no experimental cultivation of cotton should be done unless a sprayer can be used, and this remedy should be as much a part of routine work on an experimental farm as weeding or any other agricultural operation.

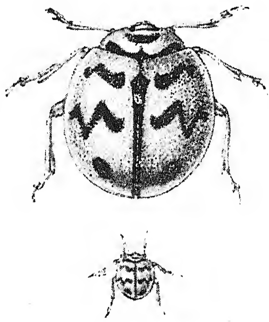
THE RED COTTON BUG *(Plate VIII.)*

Under the euphonious title, *Dysdercus cingulatus*, we have the common cotton stainer, a near relative of the American insect, *Dysdercus suturellus*. This insect may be found on the cotton at all times, most abundantly when the bolls are forming and the crop is ripening. It is a common insect throughout the plains, feeding on many malvaceous plants and originating in the jungle. Under favourable circumstances it is abundant in the cotton fields and multiplies rapidly.

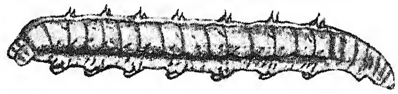
The perfectly developed insect is a vivid red, with a black diamond mark on the wings and some white lines on the lower surface. It is known as *Jhanga* or as *Lalkiri*, but does not seem to have generally impressed itself on the cultivator. The female lays a mass of little round yellow eggs on the soil or on the cotton boll. From these come small active red insects which run about the plant, and cluster on leaves or bolls, sucking out the juice. They are readily found in open bolls or on green bolls, and, if there are no bolls, on the leaves. With plentiful food they develop rapidly, the

PLATE VII.

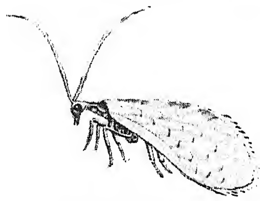
APHIS ENEMIES.



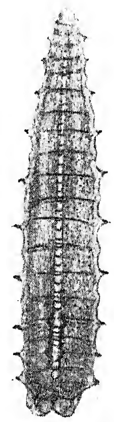
Lady Bird Beetle.



Syrphus Grub.

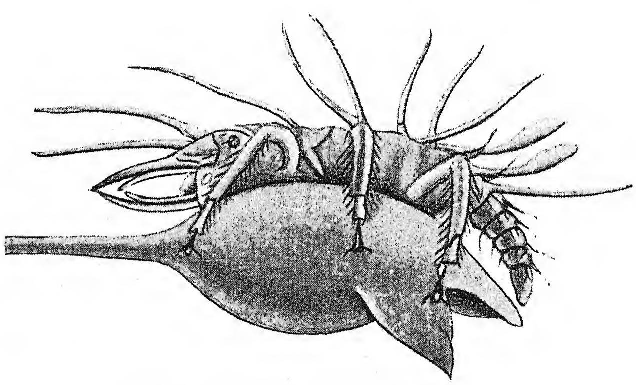


Lacewing Fly.

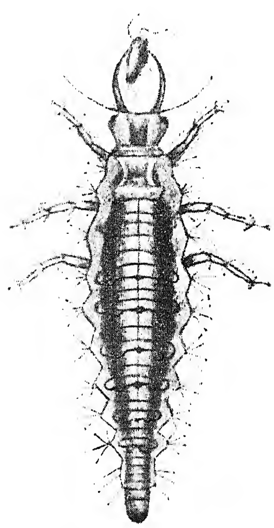


Syrphus Grub.

Eggs of Lacewing.



Lacewing Grub just hatched.



Full grown Lacewing Grub.

A J I

wings appearing as small black lobes on the back after the third moult, and attaining their full development after the last. The full-grown insect rarely flies, but runs actively. Food is obtained by the long suctorial beak, which is capable of entering the green boll and sucking out the seeds. This insect is rarely abundant enough to injure the cotton plant, and the damage it causes passes unnoticed. To all appearance it is an unimportant pretty insect which lives in the cotton and does not harm it. The damage it causes becomes apparent only when the cotton is picked, and this damage is certainly not assigned by the cultivator to its right cause. If we pick and gin the cotton from an infested field, we find (1) a large proportion of light seeds, which have been sucked out by the red bug; (2) a large proportion of bad lint, produced from bolls sucked out when young by the red bug; (3) a quantity of lint stained by the excreta of the insect; and (4) a quantity of lint stained by the small red bugs crushed in the gin.

Cotton from a field moderately infested with red bug has been found to yield about one-third of bad lint, stained or spoilt by the bug, and after the removal of this, one-third of the remaining seeds are light and without germinating power. The net result is a loss of one-third of the lint and of half the seeds.

There is, unfortunately, nothing to connect, in the mind of the cultivator, the damage the insect causes with the insect itself. The cotton is picked after the insect has done its work, and when such young insects as there are, are hiding among the lint of the open bolls. The insect works when the bolls are green, and is probably hibernating in shelter by the time the cotton-picking commences. The cultivator does not realise that the red insect which was in his fields a month before, is responsible for the bad quality of his cotton; it is doubtful if he ever saw the insect; still more doubtful if he realises that his cotton could be better.

There is no difficulty in checking the pest; give the ordinary coolie a flat basket and an empty kerosene tin or pot, having a little kerosene and water at the bottom; let him shake the red bugs off the plants into the basket, and tip them at once into the kerosene and water; he will, in a very short time, clear his cotton of bug at the expense only of a little kerosene and labour. If kerosene is not forthcoming, water heated over a fire, and occasionally warmed up again, is all that is required.

The difficulty is to get the cultivator to realise that the bug must be killed; in many places, it breeds also on the bhinda (*Hibiscus esculentus*), on the ornamental Hibiscus, and on other malvaceous plants. If he realised the importance of this pest, he could check it breeding on bhinda when there is no cotton, as it does in so many places. This difficulty should not

exist on experimental farms ; red bug should be checked systematically, and unless there is much jungle near the farm, thoroughly destroying the pest once will prevent its becoming established. A far greater amount of harm is done by this bug, than mere inspection of the growing cotton shows, and it is only when we examine the ginned seed, that we can estimate the loss. A seed that has been sucked out shows no mark, looks normal, and can be distinguished only when cut open. Such a seed will not germinate, yields no oil, and is valueless.

THE BOLLWORMS. (*Plate VIII, IX.*)

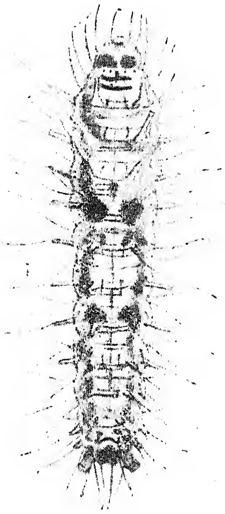
By far the most important insect enemies to cotton are the bollworms. An account of these pests is being published elsewhere, and we need here touch on salient points only. Bollworms hatch from eggs laid by the parent moths, on the bolls of cotton ; they are tiny caterpillars when they first emerge, and feed on the bracts or flower buds before eating their way into the cotton boll ; when the caterpillar has grown a little, it eats straight through the green rind of the boll, through the developing lint, and goes into the seed ; having eaten out one seed, it attacks another and so on till it is full-fed ; then it comes out of the boll, makes a cocoon in a sheltered spot and turns to the chrysalis, from which after a few days comes the moth that lays eggs and starts the fresh brood.

The details vary a little in different localities ; the cocoon may be in the soil or in the bracts of the boll, rarely in the boll itself.

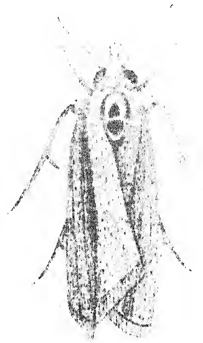
The bollworms are of two distinct kinds ; the pink bollworms, (*Gelechia gossypiella*, Saund.), a slender pinkish caterpillar ; the spotted bollworms (*Earias fabia* and *Earias insulana*), which are shorter, more thick-set, coloured in black, greenish-white and orange, with spine-like processes. Both behave alike so far as the cotton is concerned. One or other pest is found in cotton wherever it is examined in India, and generally both are found in the same field. The most careful investigation of the life-history and the habits has, as yet, not led to the finding of any simple method of checking them wholesale. For both there is one remedy, so simple as not to seem worth doing, so obvious that no one would think of it until every other remedy failed, and as effective probably as any remedy ever was, but a very laborious and tedious operation. If we consider the circumstances as a whole, we can follow the pest throughout its career, and hunt for the one vulnerable spot at which we can attack it. The eggs are very small, laid singly, not easy to find and impossible to collect or destroy in any effective way. The caterpillar is safely esconced in the boll, away from any insecticides we could bring to bear on it. The chrysalis is very small,

PLATE VIII.

SPOTTED BOLLWORM.

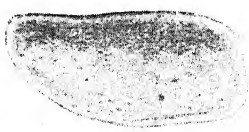


The spotted Bollworm.
Magnified four times.

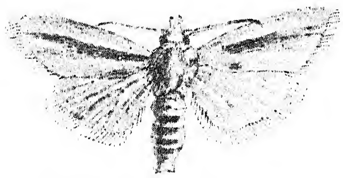


Moth of spotted Boll-
worm. Magnified
three times.

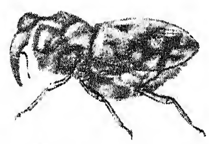
The spotted Bollworm.
Magnified four times.



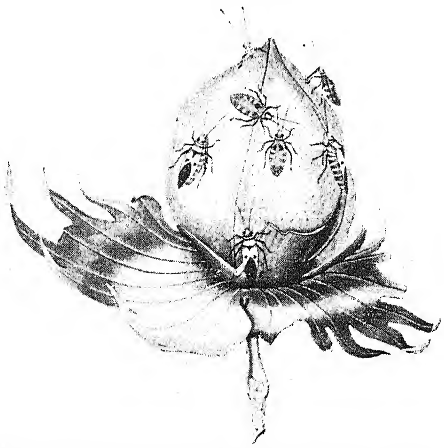
Cocoon of spotted Bollworm.
Magnified three times.



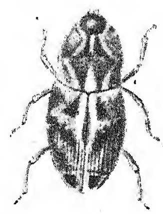
Moth of spotted Bollworm.
Twice Magnified.



The Cotton Stem
Weevil. Magnified.



Cotton Boll infested with Red Bugs. Natural Size.



The Cotton Stem
Weevil. Magnified.

A J I

very like a dead cotton bud, and not to be captured or destroyed on a large scale. The moth lives but a short time, is very small and flies only in the dusk of the evening ; clearly one cannot easily catch it. If we turn to the history of the insect throughout the year, we get little help ; cotton is sown in June and comes into bearing, say, in November. In August we find the spotted bollworms eating the top shoots of the cotton, or feeding in the flower buds ; an energetic cultivator who understood his business would capture many such caterpillars by going over his cotton and cutting them out. This is the first brood in the cotton. The moths that come from these caterpillars lay eggs on the first bolls, and the attack begins. As the bolls develop, more moths hatch out, more come in from outside, and we find both bollworms plentiful in the cotton. This goes on till the cotton ripens, when probably the caterpillars hibernate. The spotted bollworms hide away in the ground, in waste lands or in any odd corner, and there become pupæ. The pink bollworms curl up in the seed of the cotton and make a cocoon there. The cotton is picked and sold, the seed ginned and kept till next year. In March or so of the following year, out comes the spotted bollworm moth, lays eggs on bhinda or some malvaceous plant, and goes on breeding ; very often it breeds in the old cotton plants still in the fields ; if this be not possible, it hides away until the rains or lays its eggs on the stalks of a suitable plant. The rains come again, and the pink bollworm moth comes out from its cocoon ; it has to live until the first bolls are ready for it and breeds in waste lands or jungle on wild plants ; possibly it lives till August as a moth. The spotted bollworm moths breed in bhinda, in garden hibiscus, in hollyhock and in other plants, and are ready for the cotton in August.

From this, we can select several points worth our attention. There is the pink bollworm hibernating in the seed ; this can be destroyed by care, by fumigation, by testing the seeds in water. The old cotton plants need not be left in the fields to afford food for the insect in March and April as is so often the case. Bhinda and similar plants are evidently dangerous and should not be grown in cotton areas. The first brood of bollworms in the cotton should be destroyed in August, by the simple expedient of pulling off the attacked shoots and burning them. These and other measures will help, but will not seriously affect the issue in the present state of things. There remains but one remedy, *to pull off and burn every boll of the first batch that is attacked ;* if we could induce the cultivator to go over his plant boll by boll, pull off all that have signs of bollworm and burn them, we could insure at least that there would be no multiplication of the insect in the cotton by the natural laws of increase. A boll eaten when young may fall off or goes on developing ; it is valueless, in any case, but if left on the

plant it develops and opens prematurely ; the plant gives as much of its vigour to forming the bad bolls as the good. Clearly there is no loss in pulling off these bolls; there would be much gain if the first batch of attacked bolls were removed, so as to kill the first brood and check the increase. For every boll removed when small, the plant will make another ; but it will not replace old worm-eaten bolls that ripen on the plant to worthless cotton and bad seeds.

The remedy is so simple that every Indian cultivator should make it a part of the practice of growing cotton just as sowing, weeding out, picking and the like are done. An insect pest is, after all, similar to a weed, and wants removing just as much. Had we in India the educated and enterprising farmer of the United States, we could say, as Professor Comstock did in 1879, "Hand-picking ; * we should be far from advising any planter to attempt to rid himself of the bollworm by collecting these from cotton by hand," and turn our attention to spraying or other artificial remedies.

The first necessity in India is for the cultivator to realise that his cotton is attacked : when the time comes for picking, there is nothing to show that the cotton has suffered from any bollworms ; there is nothing to connect the many bad bolls with the caterpillars that were in the fields a month earlier. Should the cultivator ever realise that bollworm injures his cotton, he will probably not be far from learning the connection between the bhinda he grows in his village in April, and the extra bad attack of bollworm he gets in September. Until he has realised what bollworm is and does, the remedies that would be suitable in the United States must give place to a simpler and more direct remedy for the cultivator in India.

We may turn back to our other remedies, some of which are within the reach of farm overseers. Everything that assists the bollworms out of the cotton season, adds to the chances of a bad attack of bollworms in the season. Cotton seed that is left for sowing should be treated with Carbon bisulphide before it is put away for the winter, to insure no pink bollworms hibernating there. The old cotton plants that will no longer yield, should be pulled out before March ; it is not uncommon to see many green cotton plants in March and April, with a plentiful brood of the spotted bollworms.

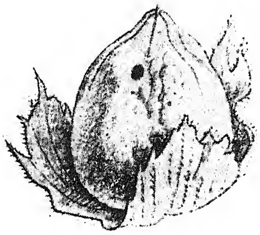
The cultivation of bhinda is a distinct help to the bollworms, especially when grown with irrigation in April and May. Whether we can use bhinda as a trap crop for the bollworms in cottons, remains to be seen. None of these are remedies for the pest; they are precautions and preventives, and

* Report upon cotton insects, p. 312.

PLATE IX.

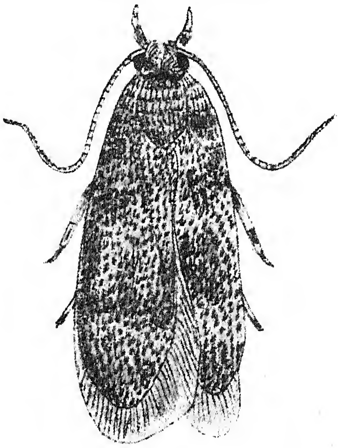
PINK BOLLWORM.

Bollworm. Magnified.



Infested Cotton Boll.

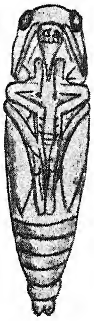
Pupa case.



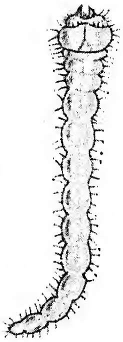
Moth. Magnified.

Bollworm.
Magnified.

STEM BORER.



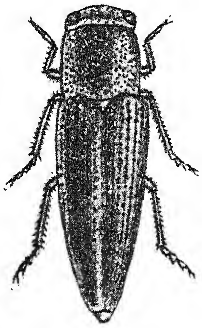
Pupa.



Grub.

Pupa in Stem.

Stem with
exit hole.



Beetle.

A J I

though they might do much in the hands of farmers, they are at present not practised by the cultivators.

It is impossible at present to estimate the loss of yield of cotton due to bollworms. Actual counts of many thousands of bolls have given from 10 to 75 per cent. of infested bolls at a picking. It is not uncommon to find that one-third of the ripe bolls have been attacked by bollworms and yield dirty lint of inferior quality. Ten per cent. was a low estimate of the total loss in the Surat District in 1903-1904, from actual counts in many fields. From 10 per cent. in a large area of cotton, we rise to any figure in cases where cotton is grown experimentally and only on a small scale. The loss that is normally spread over a large area is then concentrated in a small area. Where cotton is grown only experimentally, every possible precaution must be taken, and remedies that are impossible on a large scale become imperatively necessary ; spraying with lead arseniate becomes a necessity in such a case, as does the light-trap for the pink bollworm moth. These are discussed elsewhere and do not come within the scope of this article.

For the cultivator, there is urgent need of any measures calculated to bring home to him the nature of this pest and its work. No one can afford to neglect pests that make so direct an attack on the yield of the cotton, least of all the cultivator to whom a loss of 10 per cent. may mean his whole profit and living wage. The systematic plucking off of bolls sounds an impossible task ; it is not so hard as it sounds, and is well within the patience of the ryot if he can be convinced that it will pay.

If we turn from the cottons now grown by cultivators, to the American tree and other cottons under experimental trials, the question of varieties immune to bollworm naturally presents itself. There is at present a small amount of evidence for believing that certain indigenous tree cottons may be immune to bollworm, and it is quite possible that we may find exotic varieties similarly that are immune. Whether such varieties will remain so when cultivated on a large scale is another question ; it is at least desirable that the point should be borne in mind in estimating the comparative value of exotic and other cottons ; a cotton immune to bollworm starts on a better basis than a cotton such as Egyptian Metafifi,where the loss is very large.

This point is important in connection with tree cottons and all cottons in which the yielding period is spread over any length of time. The cottons of Gujarat, Khandeish and the Central Provinces would suffer far more were the yielding period longer ; a cotton that quickly produces its full crop of bolls is far more desirable than one that continues to yield slowly for months, or that bears more than once a year. It is imperative that the latter type of cotton should be immune to bollworm, or that it should be grown under such

circumstances that bollworm can be checked or is never introduced; the latter is probably the least likely to be possible, and the cultivation of tree cottons or of any varieties that do not yield all at one period will be profitable only if an immune variety is discovered.

THE COTTON STEM BORER. (*Plate IX.*)

If we go into a cotton field in August or September, we may find a plant here and there yellow and withered. This is the work of *Sphenoptera gossypii*, a long white grub that is living in the stem of the plant, feeding on the wood. The grub lies inside, having made a neat round tunnel up and down the centre of the stem. It will stay there till it is full grown and then turn into the chrysalis, from which in course of time comes the beetle. Both grub and pupa are readily found by splitting up these withered plants; the beetle after some days' rest in the stem, bores its way out, mates and lays a batch of eggs scattered over the field. The insect is a common one in most parts of India where the pests are known. In Bombay, Central Provinces, Cawnpore and parts of the Punjab it occurs plentifully. In Behar it has been found once, and does not yet seem to have become a pest of cotton. When the plant is young, the presence of this pest is not important; the destruction, however, grows greater as the broods succeed each other, and the total loss of plants is a serious item late in the season.

The cultivator apparently knows of the work of the pest, if not of the insect. He pulls up these plants and leaves them in neat heaps about the fields. If he went one step further and burnt these plants, he would steadily check the pest and prevent its increase. Practically every plant that withers contains a grub or pupa. It may be many days after the plant withers before the beetle comes out; if these plants were burnt, either when they withered or periodically every fortnight, practically every beetle would be killed before it was able to breed, and in the later stages of the cotton the pest would disappear altogether. The remedy is so simple and easy, that every cultivator should adopt it. It is true the destruction of the individual young plants does not in itself matter; it matters only because the beetles become numerous in the second and third broods when the loss of every bearing plant means a loss of cotton. It should not be a difficult matter to explain this to the cultivator; the whole affair is simple and straightforward, eminently suited to be an object-lesson to the agricultural classes where this pest is found.

THE COTTON STEM WEEVIL. (*Plate VIII.*)

We have lastly a pest of which little is known and concerning which we can now only sound a note of warning.

During the last few years, cotton has been experimentally grown in Behar; many varieties have been tested and some have been found to be preyed on by a hitherto undescribed insect. The Egyptian, the Broach-Deshi and other Bombay cottons, and the Caravonica have been particularly attacked, some so seriously as to preclude the idea of growing them on small areas where this pest abounds. The grubs of the pest tunnel in the stems and branches, principally in the stem just above ground. The stem swells and forms a round lump in the case of the Broach-Deshi and other Bombay and the Egyptian cottons. The plant does not necessarily die, but it sooner or later breaks off at the crown and is liable to suffer heavily, if not very vigorous in growth.

The Caravonica cotton has died practically completely from the attack of this pest. The grub, the pupa and the beetle are found in the cotton plant, the beetle eating its way out of the stem and flying away. The beetle is figured (*vide* plate); it is very small, of a dark colour, with brown and white marks; the lower surface is whitish, the legs brown, the whole body clothed in flat scales. It is active from April to November, hibernating as a grub inside the cotton plant during the cold weather. Its attack has been extraordinarily virulent upon the experimental cottons, and it is to be hoped it will not spread outside its present limits. Apparently it is an indigenous insect, feeding normally upon wild plants, but, finding cotton is a suitable food-plant, it has become abundant with abundant food.

No treatment at present known will protect cotton from its attacks, though it is hoped that further investigation may show how the pest can be attacked. It will be recognised with ease in the grub or pupa stage in the cotton plant, but cannot be readily identified from chance beetles caught in the fields.

CONCLUSION.

There are two main problems connected with cotton pests in India at the present time, which will be solved in distinct ways.

There is, first, the problem of checking the pests that lessen the yield of the staple cottons of India as grown by cultivators; second, the question of how far these pests will hinder the introduction and dissemination of improved cottons, and the problem of checking pests in these cottons.

For the cultivator, the six pests discussed above are of prime importance. The minor pests which appear here and there do not affect the issue materially. It is sufficient now to deal with pests which take toll to the extent of one-tenth of the available cotton of all India. If this estimate is near the truth, the loss from these pests is in the neighbourhood of three crores of rupees; it is of course a vague estimate, but as good as our data will give us.

How is this loss to be checked and this sum saved for the cultivator? The answer must be, by showing the cultivator the simple remedies, by teaching him something of his pests, so that he can act on his own initiative and understand how to save his crop. The crying need is for the cultivator to know that there are pests, that his cotton is not the normal amount or quality he should get, and that he can increase both quantity and quality if he will only do his best to check the pests.

The bollworm is not even known to him, as it works when the boll is green, and the ryot is not interested in green bolls. Nor does he know of the stem borer or the red bug, because they are not large, conspicuous insects that work openly. With all his inherited knowledge and instincts, the cultivator takes little heed of pests.

It is not a question of elaborate remedies or the introduction of insecticides, etc.; if we could be sure that he knew and understood, we could leave it to him to choose between adopting simple remedies and getting poor cotton. So long as the conditions remain as they are, science cannot help the ryot any further. This is the whole problem as it concerns the ryot, one that will be solved differently in different places and cannot be discussed here.

For the experiment farm, the matter is entirely different. We have a variety of plants, many exotic or unacclimatised to that locality, not yielding together and growing perhaps for long periods They are often tender plants, unable to resist pests, and not grown on a large enough scale to diffuse the pests over a large area. The result is a continual succession of pests, far more than on ordinary cultivation, acting unequally upon different plants and producing extremely curious results. If uniform results are to be obtained and if tender exotics are to be grown, pests must be checked by every device possible; the whole thing is artificial, the plant is growing under artificial circumstances, and we must adopt every means of checking the pests. The mere fact that we sow less than one acre of a particular variety means that pests are found in it to an extent that could never occur over a thousand acres, and when we consider also their entire lack of immunity to pests, we need not be surprised if cotton plants on experiment farms are ravaged by insects.

In these cases the spraying machine and the best insecticides must be at hand. Aphis can be checked with the sprayer without the smallest difficulty, and at a very small expenditure if taken in time. Lead arseniate sprayed on the plants as they form the first bolls does much to check bollworms; where pink bollworm is abundant, a lamp-trap is advisable. Bhinda should not be grown anywhere on or near the farm, nor should garden hibiscus, Deccan hemp, or any other malvaceous plants. Every individual red bug and stem borer should be rigidly destroyed; cotton, as picked, should be

fumigated ; the first plant seen to have stem weevil should be burnt, and, though no precautions can be taken against this pest, it may be possible to destroy a large proportion of the infested plants or prune off infested branches. Affected bolls and bored shoots should be burnt periodically, and no cotton plant should be allowed to grow for a day after it has yielded its seed and is finished with. These are the principal precautions, which should be familiar to every farm overseer who has charge of cotton. A good deal of trouble and attention is required, and some expenditure, far more than is within the reach of the cultivator; but if cotton is grown as an experimental plant, if new varieties are to be introduced, and hybrids obtained, the expenditure is a mere trifle compared to the other expenditure, and to the ultimate value involved.

EXPLANATION OF THE PLATES.

PLATE VI.—Winged and Wingless Cotton Aphis. Magnified.

PLATE VII.—Aphis enemies. Ladybird Beetle (*Chilomenes sexmaculata*). Syrphus Grub. (*Syrphus ægyptius*). Lace wing Egg, Grub and Fly. (*Chrysopa* Sp.) Magnified.

PLATE VIII.—Spotted Bollworm. (*Earias fabia*). Bollworm, Cocoon, Moth. Magnified. Cotton Stem Weevil. Red Cotton Bug (*Dysdercus cingulatus*).

PLATE IX.—Pink Bollworm. (*Gelechia gossypiella*). Bollworm, Pupa Case, Infested Boll. Moth.

Stem Borer. (*Sphenoptera gossypii*). Grub, Pupa, Beetle.

ORANGE CULTIVATION IN THE KHASI HILLS.

By B. C. BASU, M.R.A.C.,

Assistant to the Director of Land Records and Agriculture, Assam.

The chief centre of orange cultivation in the Khasi Hills is a narrow strip of country along the foot of the hills bordering on the Sylhet district. This may be said roughly to extend from Nongjri on the east, to Mawdon on the west, a distance of about 20 miles. The plantations commence from the plains, and rise to an elevation of about 1,500 feet above the sea level. Above these low hills and not far away, is the table-land of Cherrapunji (elevation 4,500 feet), which enjoys the unenviable distinction of having the heaviest rainfall in the world. The gardens extend for some distance into the interior along the deep valleys which cut up the southern face of the Khasi Hills. Orange trees are common enough in other parts of the district, and are found at Shillong at an elevation of 5,000 feet. At high elevations the tree does not thrive so well as in the hot steamy climate of the lower hills ; it takes a longer time to come into bearing, and the fruit is of inferior quality.

The total extent of the country in the Khasi Hills, in which oranges can be profitably grown, may cover an area of about one hundred square miles, certainly not more. A large proportion of this area is uncultivable. It is upon this small area that the greater part of Bengal and Assam depends for its supply of the orange fruit. This fact gives to its Khasia inhabitants a virtual monopoly of orange cultivation for the Bengal market, and has brought them a degree of prosperity not to be found among any other class of cultivators in Assam. They have no fear of competition, and their clan laws, which forbid land being sold out of the clan, prevent all danger of intrusion from outsiders. Although grown in the Khasi Hills, the Khasia orange is known to the outside world as the Sylhet orange, just as the Khasia lime is known in Bengal as the Sylhet lime. The misnomer owes its origin to the fact that the external trade in the Khasia orange is in the hands of Sylhet traders, who have their head-quarters at Chhatak, an important trade

mart through which a great part of the produce of the Khasi Hills is exported to Bengal.

The great earthquake of June, 1897, destroyed a large number of the orange gardens, many of the most productive of which lay on the banks of the hill streams, and owed their fertility to the silt left by the annual floods. These gardens were almost completely wiped out by the earthquake and the destructive floods which followed it. Since this catastrophe, the Khasias have been making more use of the hill sides for planting oranges, and a large number of new gardens have sprung into existence.

The orange country in the Khasi Hills is rich in agricultural produce. Besides the orange, several valuable products, such as the betel-nut, the betel-leaf and the bay leaf (Tezpat) are largely grown, and are important sources of income to the people. Black pepper is also grown to a limited extent, and within recent years the people have taken to growing coffee and arrowroot, though the cultivation of these has not yet passed the experimental stage. One wonders why the country is so fertile. The hill sides are covered with boulders and pebbles, and shew very little soil on the surface. But the boulders and pebbles serve to hold up what soil there is ; indeed if it were not for these broken rocks, very little of the soil would be left on the hill sides, the country being exposed to a rainfall not far removed in intensity from that of Cherrapunji itself.

The orange is said to do best on limestone soil. The fruit grown at Tyrna, where the soil rests on limestone, is reported to be the best grown in the district. The bulk of the crop is, however, grown on soils derived from siliceous rocks containing very little lime. Dr. Bonavia in his book on the oranges, limes and lemons of India, quotes the analysis of a sample of soil from a Khasi orange garden, which gave only ·19 per cent. of lime.

The Khasias know only one variety of orange. There is much difference in respect of quality between the fruit of individual trees, but this is not perpetuated, the invariable custom being to propagate trees from seed, a method which cannot be counted upon for reproducing the characters of the individual. The fruits of some trees have a thick rind ; in others, the skin is thinner, and the pulp more succulent. The latter are of course the better of the two, but they do not bear handling and transport so well, and consequently seldom find their way to Calcutta and other distant markets.

Orange trees are invariably raised from seed in the Khasi Hills. The Khasia orange grower has not yet learnt the art of grafting. Propagation by means of cuttings is not unknown, but it is rarely practised. Some care is exercised in the the matter of selecting the seed. The seed fruits are taken from trees selected for their good quality. They are plucked

when fully ripe. After being pressed out of the pulp, the seeds are tested by immersion in water; those which sink are taken and those which float are thrown away as unsound. The selected seeds are thoroughly washed and dried in the sun for two or three days. The seed must be sown within a short time after it has been gathered. December and January are the usual months for sowing the seed. A temporary platform is prepared with bamboos about four feet from the ground, and on it is placed a layer of finely powdered soil, four to six inches thick. The seed is dibbled in thinly, and kept covered with plantain leaves during the heat of the day. The soil is moistened with water every evening till the seeds germinate, a matter of a fortnight to three weeks at the longest. The seedlings remain on the platform till the following May or June, when they are transferred to a nursery. The nursery is prepared in a corner of a plantation, a shady spot being selected for the purpose. The seedlings are planted out about nine inches apart. The plants receive no attention in the nursery except an occasional weeding. Here they remain for two or three years, sometimes longer, until the time comes for removing them to their permanent quarters.

In the Khasi Hills and in Assam generally, seedling oranges are seldom found to deteriorate in quality. They generally come true to seed, though no doubt individual peculiarities are lost. Cases of deterioration due, I believe, to reversion are, however, not unknown. The true Khasi orange is known as *U Soh-niamtra.* Two other varieties of orange locally called *U Soh-siem* and *U Soh-niangriang* are known to result occasionally from the seed of the true orange. The first of these is a very small fruit with a deep red skin and very sour pulp. I have seen an orange very like it, growing wild in the Nambor forest in the Assam Valley. *U Soh-niangriang* is a fruit about the size of an ordinary orange, but with a thick skin, and not very unlike the Seville or Bitter orange. A third variety *U Soh-myndong* is also said to result from the seed of the ordinary orange, but I do not know this fruit well and am unable to describe it. A curious point about the *U Soh-Siem* is its name, which means the "Prince of fruits," though the fruit is utterly worthless except that it possesses a pretty appearance.

A Khasia orange garden is seldom composed exclusively of orange trees. They are always mixed more or less with other trees, *e.g.*, betel-nut, jack and bay leaf trees. The usual procedure which the Khasias follow in preparing a plantation is as follows. Early in the cold weather the forest is cut down, only a few of the largest trees being left standing. These are shorn of all spreading branches so as to minimize the shade. The cut wood is allowed to dry for a few weeks and then burnt. The burning kills everything at the time, except the

trees that are left standing. But in March, as soon as some rain has fallen, grass and other deep rooted weeds shoot up, and are dug out. Nothing more is required to prepare the ground for receiving the plants. The land receives no cultivation whatever; in fact, the rocky nature of the ground makes any kind of cultivation impossible, and there is danger of the soil, if loosened, being washed away by the torrential rainfall to which the hill-sides are exposed. The usual plan is first to plant out the clearing with plantain trees. These are planted in March, and begin to bear in fifteen to eighteen months after planting. The plantain clumps are allowed to remain on the ground for three years, at the end of which they cease to be productive and are dug out. In the meantime orange and useful trees are planted at intervals among the plantain trees. Before the time for removing the latter arrives, the other trees will establish themselves and cease to be in need of shade. The only treatment that the ground receives after it has been planted out is occasional weeding. Ordinarily, there are two cleanings during the year, one taking place in May after the spring rains which bring on a thick growth of weeds, and the other in October at the close of the rainy season.

The aspect of the land is matter of some moment to an orange garden. A garden with a northern aspect is shaded from the sun for a great part of the day. On such land, the fruits ripen late, remain longer on the trees and are not so sweet as those of a garden facing south which receives the full sunshine. Late ripening is rather an advantage in point of the price obtained for the fruits. As a matter of fact, the aspect of the land is seldom considered in making an orange garden. The area of land in which oranges can be planted is limited, and the cultivators have to put up with whatever land is available, so long as the soil is not unsuitable. Places where the soil is excessively sandy are, of course, shunned.

Orange seedlings are ordinarily transplanted when two or three years old. The time for transplanting is May and June. Holes are dug at suitable intervals with a crowbar, or a thick pointed stick, and the plants are placed in them in a slanting position. No manure is used at the time of transplanting or at any other stage of growth. No fixed distance is observed in planting the trees, the ground being so uneven and full of rocks that planting at regular intervals is out of the question. Generally speaking, orange trees are planted about 10 feet apart, but are often planted closer.

By the end of the rains, a number of leading shoots will have grown from the base of the plant. These are more vigorous and grow faster than the old stem which remains, more or less stunted, and often dies down altogether. At the end of two or three years, the parent stem is pruned off, and one or two of the most promising shoots are preserved, the rest being cut off. The

tree throws out a number of main branches a short distance above the ground. These ascend at an acute angle to the axis of the tree, and as they grow up almost vertically, they give to the tree a compact pyramidal shape, not unlike that of an English pear tree. The tree receives no further pruning till it comes into bearing. At the time of plucking the fruits, all dead and unproductive wood is removed, and the twigs, where they appear too thick, are thinned out to admit light into the heart of the tree. Mosses and parasitic growths are removed at the same time.

Orange trees begin to bear in eight to ten years from the time of sowing the seed. In unfavourable localities, twelve years, or even a longer time, may elapse before the tree yields its first fruits. The life of an orange tree is very uncertain, owing mainly to the ravages of the borer insect which destroys a large number of plants annually, and necessitates vacancies being filled up constantly.

Among the insect pests to which the orange tree is liable, the borer is the most destructive. This insect has not yet been identified, but it is believed to be the grub of a beetle. When a borer is at work, a little sawdust-like powder is found at the root of the tree, some of it sticking to the mouth of the hole through which the grub entered. At this time the insect could be easily destroyed by pushing a wire up the bore till the grub is reached. The Khasias do not seem to be ignorant of this remedy, but few seem to use it. In a recent visit which I had the pleasure of making to a Khasia garden in the company of the Entomologist to the Government of India, we found several other insects feeding on the orange trees. One of these was a species of mealy-bug, colonies of which we found infesting the roots of almost every tree that we examined. There were no borers at work at the time, but evidences of their destructive work in the past were not wanting. Many trees were found affected with canker, some so badly as to have been almost killed. The germs of this fungus disease are supposed to enter the tissue of a tree through wounds, whether caused by insects or otherwise.

Monkeys, squirrels and parrots are great pests of the orange fruit. The villagers combine to drive out the monkeys when they appear, and they are often shot. Squirrels and birds are combated with pellet bows, and various devices for scaring them. Crows too destroy a lot of fruits, but be it said to their credit that they never touch a fruit so long as its skin is intact and not until it has been eaten into by a parrot or some other animal. In some clans there is a custom of offering, out of the common clan fund, a bonus on the head of monkeys or squirrels that are killed and produced before the headman. Heavy rain in April when the trees are in blossom, is very injurious. Much damage is also caused at times by hailstones destroying the blossoms

and young fruits. These causes were responsible for the very poor crop of 1904.

The orange season commences in November, and closes in March. The export trade in the Khasia orange is in the hands of the Bengali traders, who are mostly men of the Sylhet district. During the season, these men come up with their boats to the various weekly markets lying at the foot of the hills, and buy up the oranges for cash. The practice of selling crops in advance, unhappily so common among the Bengali raiyats of the adjacent plains, is unknown among the Khasias. The usual wholesale price of oranges varies from Rs. 10 to 20 per "hundred," equivalent to about 2,300 fruits. Last year's short crop sent prices up as high as Rs. 45 per hundred. The fruits intended for export to Bengal are taken down to Chhatak, where the bulk is bought up by wholesale merchants who ship them to Calcutta and Eastern Bengal.

Khasia oranges can be preserved in good condition for many months by placing them on a bamboo trellis suspended from the roof of the house. The fruits must be sound, fully ripe and very carefully plucked, so as not to be bruised or injured in any way. They are placed thinly in the trellis, no two fruits being allowed to touch each other. From time to time the fruits are examined, and those which appear unsound are thrown away. Treated in this manner, the fruits remain good for many months, almost till the next orange season comes round. The skin looks dry, but the pulp remains juicy and sweet; in fact, it gains in sweetness by keeping. The practice of preserving oranges in this way, though simple, is by no means general among the Khasia orange growers, and very few preserved oranges are ever offered for sale.

THE STUDY OF FERMENTATION AS APPLIED TO AGRICULTURE.

By C. BERGTHEIL,

Bacteriologist, Agricultural Research Institute, Pusa.

It is a sign of the progress which the scientific study of Agriculture has made within the past few years that a plant physiologist with a special knowledge of fermentation is considered a necessary adjunct to an up-to-date Agricultural Department. Such a physiologist may perhaps be more aptly termed a "fermentologist" and his specific study may be loosely defined as "the chemical changes which take place under the influence of living matter."

Not so very long ago the chemical changes which take place in soil, whereby insoluble materials are rendered soluble and so available for plant-food, were put down entirely to the action of the atmosphere or of water or other inanimate agency. We now know that minute forms of life play a very important part in this process, and that in order thoroughly to understand the *modus operandi* of plant nourishment we must study the action of these microscopic agencies, a study which naturally falls within the domain of the agricultural fermentologist. Further, we must study the physiology of the plant, we must know all we can about its process of assimilation of food, its digestion and its means of disposing of waste products.

All these processes were formerly explained as being due to "vital force," a type of action supposed to be peculiar to living matter, but admittedly not understood, so that the attempted explanations resolved themselves into little more than begging the question. Nowadays, attempts are being made to obtain a more intimate knowledge of this "force," and in doing so we are faced with fermentation problems of the most complex nature. All we know about plant nourishment, all we know about the peculiar physiological actions which take place in plants of economic value, points to the supreme importance of obtaining as thorough a knowledge as possible of the fermentative changes taking place within the plant-cells. And we must go even further than this: under agriculture in its widest sense we

must comprise the study of the changes which take place in many cultivated plants after they have ceased to grow, such as the fermentation of tobacco or tea or indigo, though here we run close to where the sphere of the agriculturist merges into that of the technical chemist. In the course of this article we shall consider a few of the sort of problems which the agricultural fermentologist must attack, with more particular regard to those of prime importance to India.

In the first place let us consider the chemical changes going on in the soil. The chief of these, of which we have at present any considerable knowledge, is the decay of organic material, that is to say, the process by which such material, added to the soil either as residues of plants which have grown upon it, or as the excreta of animals, or as deliberately added foreign matter, becomes available for assimilation by growing crops. We must assume that such a process goes on in every fertile soil, not only because organised material placed in it gradually disappears, but also because, for the support of the plant life (disregarding an exceptional group of plants with which we shall deal later) a soil must contain a supply of nitrogen, and no other considerable source but that of decaying organic matter is at present known to exist. We know further that in the generality of cases a plant can only assimilate its food in a very simple chemical form. We do not know, however, the precise changes which the organic matter goes through in its transformation from the complex to the simple form and what agencies bring about these changes, and it is very necessary that we should so know in order to arrive at a rational understanding of plant nourishment and of the effects produced by organic manuring. Perhaps in this case, more than in any other we shall go into, our ignorance of the influence of the special conditions in India, and in other countries with hot climates, will be apparent. A little has been discovered about the cause of the decaying processes in the soils of temperate countries, and it is justifiable to assume that a few general principles established there will be found to apply in the tropics and sub-tropics ; for instance, that the breaking down action is brought about by bacteria, and that specific bacteria are responsible for specific stages of the process. But the precise nature of the bacteria responsible for each stage and of the work they do, especially those acting in the earlier parts of the process, is only partially known in other countries, and quite uninvestigated in India. It is probable that under tropical or sub-tropical conditions many new processes will be found to be involved. Light and heat are the most potent agencies in influencing bacterial action, and we know nothing of how the Indian sun will affect the question. Observations made on the rate of disappearance of organic

manures applied to the soil seem to indicate that rotting takes place very quickly, and the large and almost immediate crop returns resulting from such applications to Indian soils show how speedily the food becomes assimilable. But perhaps a better indication of this is the marvellous fertility, without any manurial treatment, of some of the soils in India which show on analysis what would in other countries be considered a deplorable lack of nitrogen. The only explanation we can at present give for this is, that whatever crop residues or other nitrogenous material the soil contains, are made the most of by undergoing rapid decomposition and rapid re-assimilation by each successive growing crop. The part of the process of decay which is best understood is the last part, a process known as "nitrification." Nitrification is a conversion of salts of amomonia into nitrates. There is good reason to believe that the majority of cultivated plants can assimilate their nitrogenous food in no other form than that of nitrates, and that therefore all organic material must be chemically broken down until it arrives at this stage before it is of any use to the growing plant. The formation of nitrates in the soil is fairly well understood, so far at any rate as the soils of the temperate climates are concerned. It is known that they are derived directly from nitrites, which are in their turn obtained from salts of ammonia resulting from earlier and little known processes in the course of the decay of organic matter. Specific bacteria have been isolated from soil, each type capable of carrying the process of nitrification through one stage, the one type converting ammonia salts into nitrites, the other nitrites into nitrates. It is practically certain that this same process is going on in Indian soils, and that the large amounts of saltpetre found in so many localities are due to no other cause.

It is of great importance that the whole matter should be investigated, that an attempt be made to isolate the particular bacteria operative in the soils of India and their nature be studied. It is admittedly improbable that a study of its bacteria will suggest better means of cultivating the soil than those already practised by the cultivator of this country, but we may at least be able to explain the underlying principles involved in the practices which he has evolved by generations of experience, and thereby avoid pit-falls in introducing methods of culture and crops of which the cultivator has no knowledge. We may also find that it is possible to increase the fertility of the land by introducing bacteria into it. A good deal has been written latterly on the subject of agricultural improvement by this last means, soil inoculation. It must be borne in mind, however, that the question hitherto dealt with has been a very special one, and, though it may prove of very wide application, it must not be confused with a general consideration of the bacteria of the soil which are essential to its fertility.

We have seen that the chief need of a growing crop, supplied by decayed organic material, is nitrogen. The living plant can obtain the elements from which it builds up its carbonaceous material through its leaves from the atmosphere, and its mineral constituents from those of the soil, but for its nitrogen it is in the great majority of cases dependent on a supply of decayed organic matter. We pointed out, however, that there was a special group of plants capable of doing without this supply, having other means of obtaining its nitrogen. This group of plants is known as the Leguminosæ, and it is with this group only that the methods of soil inoculation, of which we have heard lately, deal. The Leguminosæ are the pod-bearing plants and comprise amongst others the beans, peas and vetches. Amongst many myriads of types of bacteria which inhabit the soil, there is one at least whose special function seems to be to assist leguminous plants to grow; they attach themselves to the roots of such plants, develop and die there, forming the "nodules" or swellings which may almost always be found on the roots of any leguminous plant if it is dug up with sufficient care.

What the motive of bacteria is in doing this, is still a moot point: Dr. Moore, the latest investigator of the question, thinks that it is not altogether disinterested, but that the bacteria are parasitic on the legume until the legume develops a power of being parasitic on them, and it is fairly certain that the bacteria must derive some of their sustenance, probably their carbonaceous material, from the legume in order to grow. Be this as it may, undoubtedly they grow and develop highly nitrogenous bodies which are eventually absorbed by their leguminous host. This can go on perfectly satisfactorily in soil containing no nitrogen, or even in sand, provided the necessary mineral food for the development of the legume is available and the necessary bacteria are present. It is clear, therefore, that the bacteria obtain their nitrogen from some source other than the soil, and this source must be the atmosphere. The legume is, therefore, indirectly supplied with atmospheric nitrogen and develops at no expense to the soil except in respect of mineral matter. It is obviously an advantage to grow a leguminous crop, not only because it is obtained at no expenditure of soil nitrogen, but also because the root residues and other parts left in the soil after the crop is cut, afford a positive gain of that element, still more so if the crop is ploughed into the soil. That a leguminous crop was thus fertilising has been known from the most ancient times, but the underlying reason is a matter of only recent discovery. No sooner was the explanation forthcoming, than attempts were made to ascertain if all soils contained a sufficiency of the necessary bacteria, or if anything might be gained by adding them to certain soils. It was und that, though the bacteria were very wide-spread, they were often not

in sufficient quantity to provide nitrogenous nourishment for a good leguminous crop ; further, that there seemed to be a specific type of bacterium for each type of legume, so that the land which might, for instance, be well supplied with the necessary bacteria for beans would fail to grow a good crop of peas. In these cases it has been found profitable to inoculate the soil with the bacteria specific to the crop which it is desired to grow. It is most desirable that an enquiry into this question should be undertaken in India ; not only because of the very large number of leguminous crops commonly grown, but also because of the enormous preponderance of Leguminosæ among the indigenous weeds of the country.

There are doubtless many other organisms in the soil, contributing to the nourishment of plants grown upon it, or otherwise aiding its fertility. A whole group of bacteria capable of fixing atmospheric nitrogen without growing in conjunction with a leguminous plant seems likely to come to light, and many of its members are already known. A study of these cannot fail to be profitable ; such agents must be of immense value to the farmer and it should be the business of his scientific advisers to find out all they can about them. The case is similar when we consider the provision of the other necessary constituents of plant food to crops. We have reason, for instance, to believe that carbonaceous material in the soil, even if it be not for actual food, plays some very important part in plant nourishment ; what is its precise function, and in what form it is of use to the plant, are points for future investigation to determine ; but that a study of its formation, as of that of many other substances essential to plant life, will involve a consideration of fermentative actions, bacterial or otherwise, there can be little doubt.

Finally we have to look upon the agricultural fermentologist in his sphere of bacteriologist as something of a plant doctor. Plants, like animals are liable to suffer from many diseases due to the attack of bacteria, and it must be part of the function of agricultural bacteriology to study these diseases and find means of cure. As compared with diseases of animals, little is known about these at present, but it is probable that with its moist hot climate, eminently suited for bacterial development, India will afford a happy hunting ground for their study.

We have now perhaps sufficiently indicated the importance of a study of the fermentative action of bacteria in the soil, and in the plant, to agriculture. We will pass on therefore to the consideration of another sphere of agricultural fermentology, a sphere in which the knowledge to be obtained may be less immediately 'applied,' but is just as fundamental to a thorough understanding of the principles of agriculture, that is, the application of the study

of fermentative changes to plant physiology. Plant physiology is the science which deals with the life processes of plants, their development from seed, their means of obtaining nourishment, their digestion, their growth, their reproduction and death. It is obviously important that the cultivator, whose industry depends upon the development of plants, should know as much about these things as possible, or at least that his scientific adviser should so know and be able to communicate to him the more practical outcome of the knowledge. In a study of such complex matters, however, it is clear that more than superficial observation is necessary. We may know that certain plants grow best in certain soils, that certain manures tend to the rapid development of some plants (or to that of special parts of them), and not to that of others ; we may analyse the soil carefully, and we may know the elements involved and the quantities of them in the complete plants. But this is not enough; we must take a closer look into the economy of soil and plant before we can understand the latter's life functions. We must find out how each element necessary to those functions enters the plant and how the plant transforms the food assimilated until it arrives at the complex forms we find in its cells. In short we must realise that, just as we have seen the soil is the seat of constant chemical changes, so also the plant is not a stable entity, but that its development is the expression of continuous transformations in its cells, and immediately we try to examine these processes of transformation we are faced with fermentation problems. It must not be understood, however, that bacteria play any essential part in these ; but the chemical processes going on in the plant cells are as truly fermentations, in the sense we defined the term, as are the actions of bacteria, moulds, yeasts, or other lowly organisms, since in both cases we have to deal with "chemical changes taking place under the action of living matter."

The distinction often drawn is a purely superficial one, and it is only misleading to talk about the bacteria etc., as "organised ferments," and the agencies acting in the living cells of higher organisms as "unorganised ferments." It is sufficiently probable to be nearly a certainty, that both are in their essential actions the same, that both act by having a specific power (whether it be looked upon as a power of secreting a certain type of substance or exerting a certain type of force) of bringing about chemical changes of quite another order to any we can so far reproduce in our laboratories. Let us take a simple instance and see what happens when a seed germinates. Most seeds contain, besides the embryonic plant, a store of food material to nourish the young plant during the early stages of its growth, before it develops powers of obtaining its own food from the soil and atmosphere. This store is usually a complex mixture of starchy foods with fats and oils. All

these bodies are, as a rule, insoluble in water, and therefore not subject to assimilation by the young plant as they stand. Nature has, however, provided it with agencies capable of producing changes in these food stores, which render them soluble, and this in some way quite other than any we know of in our laboratories. These agencies are ferments. They are commonly called unorganised ferments or enzymes, in contradistinction to organised ferments by which bacteria, yeasts, etc., are implied. As we have already pointed out, however, this distinction is probably quite an artificial one, since the organisms almost certainly produce many, if not all, of their specific actions by means of a production of enzymes just as a plant cell does.

The study of enzymes is quite in its infancy ; we do not even know for certain whether they are chemical entities or forces, one school of workers holding the first view, another the second ; but since, even if they be forces, they seem to be invariably demonstrated by certain definite chemical types, it is not very material which school is in the right, and it is more convenient for the present to look upon them as chemicals endowed with powers of bringing about special reactions. What we do know, however, is that these ferments are very widespread in living cells both animal and vegetable, and in single-celled as well as many-celled organisms, and that they play a very important part in life processes.

To return, however, to our germinating seed. We have seen that the embryo is provided with enzyme in its cells capable of dissolving the food materials in the other parts of the seed. This action takes place as soon as the seed is placed under proper conditions of warmth and moisture, and the food material is assimilated by the young plant and the latter is started on its growth. With growth more enzyme is produced, more food dissolved, and the process continued until the first leaves are above ground, and rootlets are formed so that the plant can nourish itself from the soil and atmosphere ; and then begin a whole series of processes in which ferments are probably intimately concerned. Food comes in at the leaves as carbonic acid gas, and at the root as nitrates and other soluble salts, and from these simple beginnings the whole complex fabric of the plant must be built up. Needless to say this is far beyond anything we can do with the aid of our most modern chemical and physical knowledge and appliances, whilst the plant can do it without much rise in temperature, without any potent chemicals as we understand them, and without any physical condition such as we understand and cannot reproduce. We hope that the study of enzymes will explain much of this, and already glimmerings of understanding are coming out of the darkness. With knowledge of this kind we may hope to be able to approach problems of plant nutrition

and development from something other than the more or less empirical standpoint of to-day, and to understand and perhaps influence the formation of the economic products for which so many of our plants in India are cultivated. I hope in a future article to touch upon the way the study of fermentation enters into that of the treatment of many crops and other farm products.

NOTES.

AGRICULTURE IN EAST AFRICA PROTECTORATE.—The Protectorate is still in its infancy with regard to agriculture and cannot yet be said to have developed any one predominant crop. Crops that have been successfully grown include potatoes, wheat, barley, sisal-hemp, rhea (*Boehmeria*) and tobacco. The curing of tobacco has yet to be taken in hand before it can be proved to be suitable for more than local consumption. Experiments in Sericulture have also been successful.—(H. M. L.).

* * *

CULTIVATION AND PRODUCTION OF SISAL FIBRE IN THE PHILIPPINES.—The increased demand for Sisal fibre, one of the main uses of which is a "binder" twine for use in grain binders, has led to increased activity in the cultivation of this fibre in the Philippines. Here it is customary to devote the drier and sandier lands to the cultivation of this plant. Machinery has as yet not been introduced into the Philippines, and the fibre is prepared by maceration or retting or by one of the several "dry" processes. These latter, though they give a very superior product, are not in general use as they are too laborious. With the introduction of machinery there is every prospect of the establishment of a profitable industry.—(H. M. L.)

* * *

YEAR BOOK OF THE DEPARTMENT OF AGRICULTURE OF THE UNITED STATES OF AMERICA.—The Year Book of the United States Department of Agriculture for 1904 has been published, and contains as usual a large amount of useful information. The present volume is more compact and handy than those of former years, being limited to some 700 pages. The total budget devoted to Agriculture for the current year amounts to 5,944,540 dollars, or nearly £1,200,000. The total number of salaried persons constituting the body of the Department of Agriculture is 4,504, and in addition nearly a quarter of a million special correspondents and reporters who, although receiving no financial remuneration from the Department, co-operate with it and render it much valuable service.—(B. C.).

* * *

INDIAN WHEAT EXPORTS.—The following tables will show the position which India holds among the wheat-producing countries of the world, and the important part it has recently taken in the supply of that grain to the United Kingdom :—

WHEAT CROP OF 1904.

Countries.	Bushels.
Russia	706,646,000
United States	552,400,000
British India	357,162,000
France	296,606,000
Austria-Hungary ...	203,998,000
Italy	150,400,000
Germany	139,803,000
Argentina	120,598,000
Spain	110,000,000
Great Britain	39,083,000

IMPORTS OF WHEAT TO UNITED KINGDOM FROM 1901-02 to 1904-05.

Countries.	In thousands of Cwts.			
	1901-02.	1902-03.	1903-04.	1904-05.
India ...	7,428	11,908	23,144	29,083
Russia ...	3,061	13,721	19,331	28,823
Argentina ...	4,973	11,856	17,490	24,085
United States	41,584	32,035	12,897	4,558
Canada ...	8,302	11,471	8,355	3,547
Australia ...	6,048	79	6,322	12,758

(B. C.)

* * *

Agricultural Products of the Shan States.—In a lecture before the Society of Arts on April the 6th, Sir J. George Scott, K.C.I.E., devoted part of his address on "The Products of the Shan States" to a brief summary of the agricultural products of that part of Burma. Experiments have shown that barley and oats grow well, for the latter of which there is an immediate market in India, where the oats are more useful for fodder than for grain. English fruits grow freely, but rapid carriage is required before there can be any outlet for the produce; oranges also grow well and produce freely. Coffee has been successfully cultivated, while tea is found wild, and simply awaits the arrival of planters with the necessary knowledge and machinery. Tobacco is grown in large quantities, but no attempt is made to cure it. Of industrial plants, cotton, hemp, indigo and a variety of rubber-yielding creepers are all cultivated or found growing freely. The staple of the cotton is, however, very short. At the present time lack of communications is the chief drawback to an active development.—(H. M. L.)

* * *

Since the issue of the revised form of the "Tropical Agriculturist" under the auspices of the Agricultural Society of Ceylon, Mr. E. E. Green, Entomologist to the Government of Ceylon, has contributed regular monthly notes on the insect pests observed. These notes should be read by planters in South India, many of the pests of rubber, coffee, tea and other crops of Ceylon being similar to those found in the Nilgiris, Shevarroys and other hill districts. Mr. Green finds that cotton in Ceylon is attacked by pests similar to those of India and is impressed with the danger of carrying cotton over from one year to another. Caravonica cotton appears to thrive in Ceylon, the virulent stem weevil of Behar not having as yet attacked it in Ceylon, and its pests being the same minor ones as observed at Pusa. Those interested in the prevention of injuries to palms should consult the "Tropical Agriculturist," and we shall await with interest the result of Mr. Green's experiments in the treatment of palm-weevils.—(H. M. L.)

* * *

The Treatment of Brown Bug of Coffee.—Since the publication of the Preliminary Report on Insect Pests of Coffee, planters in the Nilgiris have experimented with insecticides as a method of checking the increase of this virulent pest. Mr. C. H. Brock, the Honorary Secretary to the Nilgiris Planters' Association, has reported failure from the use of Crude Oil Emulsion and success with Rosin compound. The latter was the wash recommended, being easily made on the spot and costing only Rs. 3 per 100 gallons. The wash is valuable chiefly as a check when the young bugs hatch out and commence to spread over the fields; in bad cases a very large area will die in a short time, as the result of a sudden large increase in the numbers of the bug. In such cases, spraying is a certain check and, from the experiments conducted by Mr. Brock, spraying is also valuable as a regular method of destroying bug on any infested coffee, if applied at the time when the young hatch out and become active. Coffee-planters, who have experienced the

havoc caused by brown bug, will welcome a reliable method, and it is probable that when the coffee industry revives, spraying will be more largely adopted as a regular check on the increase of this pest.– (H. M. L.)

*
* *

Green Bug on Coffee.—Green bug is one of the notorious pests that helped to destroy the coffee industry of Ceylon and is not unknown on coffee in the West Indies. Hitherto it appears to have been confined in India to the Pulney Hills, but it is stated that it is now spreading through the Wynaad and into the Nilgiris Should the pest spread, the newly infested coffee districts are likely to suffer very heavily, and coffee planters may be cautioned to keep a very sharp watch for this pest. The scale is smaller and flatter than brown bug, green in colour, with a sinuous black line visible on the upper surface. It infests coffee in the same manner as the brown bug and spreads with greater rapidity. Possibly its spread in South India will be limited by climatic conditions; on the upper slopes of the Nilgiris, brown bug is dormant for a part of the year, the eggs remaining unhatched under the scale of the mother insect; whether the green bug must equally remain dormant is not known, and as this bug produces living young, it can not pass through a long period in the egg stage. Either it must be continually active, or it must remain dormant as an adult; in either case its behaviour (or treatment) will differ from that of brown bug. Where it appears, the precautions mentioned in the Preliminary Report on Coffee Pests should be at once adopted.—(H. M. L.)

*
* *

The Bulletin of the Philippine weather Bureau for April, contains an interesting account by R. E. Brown, S. J., of a hairy catterpillar, closely similar to those which ravage the crops in India. The insect in question is an omnivorous feeder, refusing little in the way of green vegetation, with the result that it becomes extremely abundant. Among its food-plants are mango, mangosteen, several figs, tobacco, tamarind, citrus plants of several species, hibiscus, sapodilla, custard apple, rain trees and others; these were its food-plants in one garden, but the author justly observes that "if the life history of the insect had been studied for a longer period, it would probably be found that to give a list of its food-plants, we should have to enumerate the flora of the Philippines." India does not lack pests, but none so voracious have yet been observed, and we may picture the ravages such a pest would cause in an Indian botanical garden or fruit orchard.—(H. M. L)

*
* *

The Influence of Nodules on the roots of Leguminous Plants.—Experiments conducted at the Michigan Experiment Station have conclusively shown that nodules on the roots of leguminous crops have the effect of greatly enriching the plant, both as a feed and as a fertilizer. In one experiment conducted there, it was found that the leaves and stems of inoculated soy-beans carried $17\frac{1}{4}$ pounds of protein per hundred pounds of the fodder, whilst those not inoculated and carrying no nodules had but 11 pounds per hundred of protein, as the average on two years' experiments. When both years were taken together, the content of protein in the stems and leaves was nearly 57 per cent. greater in the inoculated plants. With cow-peas the inoculated plot was 47 per cent. richer in protein than the one in which the plants were free from nodules on the roots. The importance of this increased feeding value of the crop when inoculated, or carrying nodules on the roots, is great, and should not be lost sight of when deciding whether to inoculate a crop or not. When used as an improver of the land only, a crop carrying nodules on the roots is more valuable by nearly

50 per cent. than a crop without nodules. Inoculated soy-beans provided 113 pounds of nitrogen per acre, whilst an uninoculated crop only furnished 75 pounds. Inoculated cow-peas—that is to say, peas carrying nodules on the roots—furnished 139 pounds of nitrogen per acre, whilst a crop without nodules only supplied 118 pounds. The seed of soy-beans was fully 16 per cent. richer in protein when saved from a crop with nodules on the roots than when saved from a crop without nodules on the roots. This means a much higher feeding value for the nodule-bearing crop.—(*The Southern Planter.*)

***

ORANGE INDUSTRY IN THE WEST INDIES.—In the orange industry of the West Indies, a stage of development has already been attained when it is no longer sufficient to consider the quality of fruit only. In the markets of both America and England definite trade customs have arisen which it is necessary to take into consideration before competition in their markets is attempted. Thus it has become, not only advisable, but essential to pack fruit in standard boxes 12½″ by 12½″ by 27″ (outside measure) with a single median partition; each orange should be wrapped carefully in white tissue paper after close examination of the individual fruits to discard any in the least degree blemished. The fruit should, by the same examination, be carefully graded, and each grade should then be packed in layers and the number and grade marked outside each case. Too much care can not be devoted to producing uniformity. Such are the controlling factors as set forward by Mr. H. Hesketh Bell, C.M.G., Administrator of Dominica, in a paper on the cultivation of orange in Dominica, recently printed by the Imperial Department of Agriculture for the West Indies.

In discussing the local conditions, he lays stress on the choice of stock which should be used for the purpose of taking the bud. In Dominica choice favours the common wild sour orange. This is more resistant to disease than other stocks, but in this matter each country must determine by actual trial the stock most suitable to the local conditions.

The yield in Dominica is large; thus a seven years old tree will bear as many as four hundred fruits, while a mature tree in full bearing will give 5,000 fruits. Of the varieties most suitable the Jaffa orange is recommended. Other good varieties are Parson Brown, Valencia Late, Boone's Early and Mediterranean Sweet. A series of varieties, including early and late fruiting kinds, is recommended to any one starting an orange grove.—(H. M. L.)

***

INDIAN POTATOES FOR LONDON.—It is known to only a few that India can grow new potatoes and land them in Covent Garden Market, London, in the months of February and March, to be sold at from 2*d.* to 6*d.* a lb. and retailed again in the West End shops as a delicacy at 1*s.* a lb. The experiment was carried out a few years ago at Dalsing Sarai for a couple of years, several tons being shipped from Calcutta to London with success, but the enterprise was abandoned not from any failure in the packing, shipping or sale in London, but entirely from the fact that the lands at Dalsing Sarai were unsuited to the growth of potatoes which were overcome by disease and gave an unprofitable return per acre. In many parts of India the soil is well adapted to the growth of potatoes, and where this is the case, disease can be easily checked, and a trial of the experiment is strongly recommended. The potato selected should be an early Kidney, such as the Jersey potato or Myatt's Ashleaf. Very satisfactory results were also obtained from the Naini Tal Magnum Bonum, but this being a late variety could not reach London before March when the price begins to sink. Planting should be done as early as possible in October, so that the potatoes may be lifted in January

and delivered in London in February and March, before the inflow of supplies from Jersey and the Canary Islands. The seed should be of the best and should be procured from England or better from Australia, where potato disease is less prevalent. The land should of course, be heavily manured, oilcake being excellent for this purpose. The potatoes on being lifted should be very carefully handled, dried for a few hours in the sun, and each potato wiped with a piece of Chamois leather. They are then sorted into two grades, packed in neat boxes 15″ by 15″ by 6″ to hold 28 lbs. and lined with paper. These boxes were shipped from Calcutta by the City Line and delivered in London in 26 days. The potatoes arrived in perfect condition, and were sold for 2*d.* a lb. wholesale. The average cost of sending the potatoes home was £6 per ton or two-thirds of a penny per lb. Should any further information be required, it can be obtained on application to the Director, Agricultural Research Institute, Pusa, Bengal.—(B. C.)

* * *

COTTON IN THE WEST INDIES.—Five years ago, sugar was the staple crop grown in Barbados and, owing to the lower prices then prevailing, planters were thinking what else could be grown either as a staple or as a paying subsidiary crop. Sugar is still the staple crop of this island, but two other very valuable subsidiary crops are now exported, either of which might, if sugar falls again, maintain the prosperity of the island. These crops are bananas and cotton, both grown for export to the United Kingdom. Cotton was experimentally grown upon a few estates in 1902-1903. The cultivation has since extended and is already a very paying one; The figures are given in the last number (No. 2 of Vol. VI.) of the West Indian Bulletin in a paper by J. R. Bovell, who himself has been largely instrumental in promoting the growth of cotton. Ten cotton growers kept accurate accounts of all charges incurred in the cultivation, ginning, shipping and the like, on a total area of 95¼ acres; the average weight of lint was 235 lbs. per acre, of seed 553 lbs; the average amount realised from lint and seed was Rs. 212, the average cost was Rs. 62 per acre, giving an average profit per acre of Rs. 150 net. The only items not included under expenses are cost of supervision (European) and interest on capital. Mr. Bovell's figures are interesting reading and show that the average price for lint was between twelve and thirteen annas per lb. over the whole area. This is a satisfactory state of affairs and extends to a large number of islands; over one thousand acres are under cultivation in Barbados, St. Kitts, Nevis and St. Vincent, and smaller areas in the remaining islands. The total acreage in 1902 was 400, in 1903, 4,000, and in 1904-05, 14,000. The industry is expanding as rapidly as can be expected, seeing that the first sea island cotton was grown there in 1901-02. The total production can never very greatly affect the world's output, few of these islands having a total acreage of more than 100,000, of which perhaps not more than one fifth will be available for cotton. One exceptional return, quoted in the West Indian Bulletin, was obtained by a particularly keen planter: on 22 acres of land sown in cotton and maize, he realised total gross proceeds of Rs. 7,415, with total expenses of Rs. 1,564, leaving him a net profit of Rs. 266 per acre. The value of this industry is most clearly shown by the rapidity with which it has been taken up and made to pay; the initial stages of a new industry are rarely profitable, but the West Indian planter, aided by the Agricultural Department, appears to have found a profitable thing in cotton. The success is, of course, due to the introduction of the one kind of cotton that suits the West Indies, namely, Sea Island; it thrives under that delightful climate, it is not infested with the bollworms, stem weevils or other really voracious pests and, in

the garden cultivation of Barbados, it yields luxuriantly and quickly. A variety of cotton that will give equally excellent results in the hands of the Behar planters has yet to be found or produced.—(H. M. L.)

NEW BOOKS.

(DAIRY FARMING IN INDIA. *A practical Manual by Majors* D. J. MEAGHER *and* R. E. VAUGHAN *of the Indian Army. Office of the Superintendent of Government Printing, Calcutta*, 1904.)

We welcome the publication of "Dairy Farming in India" by Majors Meagher and Vaughan, a book which will be found useful as a guide not only for the establishment of Military Grass Farms, but to those wishing to undertake dairying in India as a private enterprise. While we recognise the practical experience which underlies the authorship, we cannot entirely pass unnoticed the lack of complete information regarding foods in the opening chapter. Thus in the enumeration of the best food grains, no mention is made of oats and maize. In many parts of India these will be found the cheapest and most nutritious of any grains, if mixed with a judicious amount of cake or pulses. Indeed, oats by themselves can hardly be beaten as a concentrated food, and maize, though lacking somewhat in protein, is excellent when balanced by cake. Maize, too, is probably the cheapest cattle food in India, if the cob and grain are fed together ground to a coarse meal. Considerable experimental feeding has been conducted in America to throw light on this question, and the information secured has favoured the grinding of the grain and cob together. It is assumed that pure meal packs in the digestive organs, and is not so readily permeated by the digestive fluids as is the grain and cob meal, the cob making the mass more porous. The remarks on Silos are entirely out of date. More recent and complete information can be secured by a study of the principles and methods of American siloing. The book is profusely illustrated with types of cattle and buildings. It is hoped that the authors may see their way to providing an index to their next edition. The volume is fairly well got up, and the printing, paper, and illustrations are a credit to the Government Printing Press and the Survey of India Office.—(B. C.)

NOTICE.

The Agricultural Journal of India.

A Quarterly Journal of Agriculture and allied Subjects.

Subscription ... Rs. 6 0 0 per annum in advance.

" 2 0 0 per part.

CORRESPONDENCE concerning subscriptions, changes of address, delay in receipt of the Journal and such like matters should be addressed to the Office of the Journal, Pusa, Bengal.

Articles intended for publication should be sent to the Editor, the Inspector-General of Agriculture, Nagpur, Central Provinces, India. Contributors are invited to sign their contributions. All communications must be authenticated by the name and address of the writer, whether intended for publication or not. Contributors will be given, free of charge, fifty copies of their contributions, and will be supplied free with one year's issue of the Journal.

THE RENOVATION OF DETERIORATED TEA.

By H. H. MANN, D.SC.,

Scientific Officer of the Indian Tea Association.

At any moment during the past twenty years the question of the treatment of old and deteriorated tea has been an anxious and much-discussed problem over almost the entire extent of the tea districts of North-East India. In fact it is no new observation that under the conditions of tea culture in India, the bushes rapidly lose the vigour of their early days and, after a time varying from ten to twenty years from planting, may be said to have passed their prime, and can only be kept from deteriorating by very careful treatment.

HISTORY OF THE SUBJECT.

This fact, due in part to the unnatural conditions under which the tea plant is cultivated, became very obvious in the very early days of the industry. Though the first gardens only date back at the most to the late thirties (1835-1840), yet before ten years were past, as the records of the Assam Company show, complaints were made that the older planted areas had begun to yield less than they had done when younger, and less than was expected. Of course, we now know that deterioration such as this was largely, if not entirely, due to a vicious system of managing the bushes and collecting the crop, but the fact remains. By the later sixties (1865-1870) some of the planters had commenced to talk about the necessity for manures, but the question was not taken up, and a few tests with fertilisers not having been very successful, their use as a method of dealing with deteriorated tea was put almost entirely on one side for over thirty years.

Owing to the very expensive character of manuring and to its very partial success at that time, it became the rule in many districts to make up for the annual deterioration of the older tea by planting new areas every year. Thus it was often the case that five or even ten per cent of the existing area was put out in new plant each year, with the idea that as

6

soon as the new tea came into bearing, a corresponding area of old cultivation should be abandoned and allowed to revert to its original jungle. Sometimes the abandonment was carried out; sometimes, and more often, the old cultivation was still retained in the area of bearing tea. The former, while agriculturally a disgraceful process resembling the *jhuming* system of the Indian hill tribes, was commercially sound; the latter, in constantly increasing the area under cultivation while the yield did not increase or only increased in a smaller ratio, was both agriculturally and commercially unsound. That this is the case is sufficiently obvious with the least thought. There is a constantly increasing area, demanding a constantly augmenting labour force both for cultivating the land and plucking the crop, and a crop not increasing in the same proportion, and hence costing more per pound each year. The result has been, ultimately, a crisis in many gardens, and the method is now almost entirely a discredited one.

While such methods of counteracting the deteriorating effect of age in tea gardens and tea bushes were being used, the discovery was made that bushes, which had gone very far below their original condition, could be brought again into vigorous yielding condition by 'heavy pruning.' By this type of pruning is meant any system which involves cutting out entirely the growth of shoots made in the current year, and so leaving on the bush only wood more than one year old. The tea bush has a marvellous power of throwing out new shoots at apparently almost any point of the old wood on the plant, so that when all the younger wood is cut out, new shoots make their appearance from the older growth, and, provided the soil is in a satisfactory condition and not exhausted, this growth arising from the older wood shows greater size and vigour than that produced on the younger shoots only grown during the previous season. The advantage of this was quickly seen. By periodical 'heavy prunings' it seemed as if it would be possible to keep old bushes in full vigour indefinitely. The 'heavy pruning' conducted under the influence of this idea became, year by year, heavier and heavier until in the early nineties (1890-1895) it became fashionable in Upper Assam actually to cut down to the ground any tea which had deteriorated in yield, and allow new shoots to come from the 'collar' of the plant or even below. This was called 'collar-pruning.' Advantageous and even necessary as such treatment was in many cases, the system just described took a far too great extension. Hundreds of acres were collar-pruned when the tea was suffering from causes for which collar-pruning was no remedy, and it was hardly recognised enough that such drastic treatment should only be adopted as an extreme, and then only when it was quite evident that the deterioration was due to something for which collar-pruning is a remedy.

The present state of the subject is then somewhat as follows. The old tea throughout the Indian tea districts of North-East India has mostly declined or is declining in value. There is comparatively little plant more than thirty years old which does not show this decline ; and much, the age of which only little exceeds twenty years, is in the same case. The older system of abandonment of the old areas and planting out new to correspond, cannot in many cases now go on owing to the lack of available land, and the essentially wasteful character of the method is becoming more and more realised. The planting of additional areas in a garden to make up for the decline of the old tea has been generally recognised as being commercially unsound. The renovation of old areas by heavy and collar-pruning, though still adopted, and rightly adopted in many cases, has been proved not to apply under all conditions. Manuring is, as yet, in its infancy as a practicable and regular method. The time is therefore opportune for a discussion of the whole question, as to the special causes of deterioration, the signs by which each of them may be recognised, and the methods which have hitherto proved, both in experiment and in practice, most competent to stay the decline in the yield and quality of older tea, and of thus maintaining the value of our older areas.

SIGNS OF DETERIORATION.

It is not always, however, that the decline in value of a block of tea is recognised until it has already got into a very bad condition. Until recently the keeping of records for each section of a garden was the exception rather than the rule, and, without this, it is almost impossible to recognise the first drop from the original yield. I well remember visiting a garden in one of the districts of Assam some years ago, which had been making brilliantly successful years, and was looked upon as one of the show places of the district in which it lay. The yield had been keeping up, or rather its decline had not been noticed owing to the exceptionally fine returns which were being given by young tea newly in bearing. And yet the bulk of the older tea was undoubtedly rapidly deteriorating. Luckily, the matter was recognised in time, but I quote this as an example of how brilliant results may sometimes hide the commencement of serious mischief.

But what are the first indications by means of which deterioration in tea may be at once recognised? The resultant loss in yield is usually by no means the first sign, for this can be often maintained by harder or closer plucking or other means for some years after deterioration has set in. Probably the first point noticeable in most cases is the change in colour of the tea bushes. Thoroughly vigorous tea, even if of the lighter coloured *jats*, has a darker

appearance than unhealthy plant, and the leaves have an oily appearance very difficult to describe but which can hardly be mistaken. Then, too, the whole surface of the tea, at the beginning of the season, seems to be growing; the outer parts of each bush show that each shoot is throwing out new growth which is itself vigorous and with the oily appearance already stated. On the other hand, if the general colour of the tea in the season is an unhealthy yellow, if the difference between the vigour of the growth (in March or April) at the outside of the bushes and in their centres is great, if the shoots, which do appear quickly cease growing and turn *banjhi*,* then it is time to consider the cause of the decline which has manifestly commenced. In nine cases out of ten tea which presents these signs will, if examined in May or June, be found to be attacked by Red Rust *(Cephaleuros virescens)*, a sure indication of weakness in the bushes all over our tea districts. If this is the case, the yellowish colour of the bushes will, at that time of year, be interspersed with many shoots bearing variegated leaves. These shoots are practically always '*banjhi*,' and if the second year's wood from which they rise be examined, it will be found almost always to bear the characteristic fruiting organs of the alga which is known as 'red rust.' †

Tea, which has the unhealthy colour just described, and has red rust in any large amount, is evidently beginning to 'go off,' and the result will sooner or later be seen in thin flushes and loss in yield. And in this connection may I enter a plea for the universal adoption of a system of records of the yield of each block at every plucking on all gardens? I know such records are being increasingly adopted, but until this system is universal there is always the chance of a planter or a tea company living in a fool's paradise until a crisis occurs and several unprofitable years follow before the tea is brought into a yielding condition again. Loss in yield should be capable of immediate check, and the cause ascertained at once and remedied, if a garden is to be kept up to the mark under the high pressure conditions of modern tea planting.

Accompanying the decline in yield the appearance of the wood on a bush usually changes. There are grey lichens on the stems of nearly all tea bushes, but they only occupy part of the surface; in unhealthy plants these lichens seem quickly to spread over the whole, giving the wood a peculiar greyish appearance which is generally described by the term '*hide bound*.' Though this term has no definite scientific meaning, yet in a '*hide bound*'

* *Banjhi* (= barren) is the term applied to shoots on which new young leaves have ceased to be formed.

† For a full description of this disease, *see* 'Red Rust; a serious blight of the Tea Plant,' by H. H. Mann and C. M. Hutchinson, published by the Indian Tea Association, Calcutta, 1904.

bush the bark always seems distinctly harder than on a thoroughly healthy plant. The most characteristic feature is, however, the fact that leaf growth seems to cease in large measure except from the younger wood on the top of the bushes. The result is that a '*hide bound*' bush always looks hollow, and while it may appear fairly vigorous on the top, an examination below indicates the unhealthy condition in which it really is. The usual and often the right prescription for such bushes would be heavy pruning. This is not, however, always the case as will be realised later.

CAUSES OF DETERIORATION.

We have described the most obvious signs of an unhealthy deteriorating bush, and the special causes which produce such unhealthiness must next be considered. Deterioration in tea, apart from incorrect management, must be due either to exhaustion of the land, or exhaustion of the bush, and it has been a common subject of discussion among planters as to which is usually first noticeable. It seems now clearly proved that the question does not admit of a definite and generally applicable answer. In many cases, and in my experience notably in the Duars, the bushes show signs of being worn out long before the soil could be considered exhausted. In others, the marvellous results obtained by adding manure to the land, without any further treatment, show beyond cavil that the bushes would yield and continue in good health if only the soil was rich enough, or the plant food present in an available condition. I am strongly of opinion that in by far the greater proportion of cases it is exhaustion of the soil, coupled with incorrect treatment of one sort or another, which brings about the first decline in the value of areas of tea. At any rate it is no use touching the bush until one is certain that the soil is in good enough condition to enable the bushes to respond to the treatment. But how to ascertain whether there is anything wrong with the soil ?

DRAINAGE.

In the first place, it should be made certain that the drainage of the land is satisfactory. This, I think, can be done on the spot, by three or four tests. These tests concern (1) the moisture in the subsoil in the cold weather, (2) the depth of the subsoil water in the rains, (3) the rapidity with which the heavy rain disappears through (not over) the soil on a piece of flat land. With regard to the first of these matters, it can easily be tested by digging a hole two feet deep, weighing, say, ten pounds of the damp soil at the bottom of the hole, drying it in a warm place near the boiler for, say, two days, and re-weighing. Now the maximum amount of

water which ten pounds of different classes of *dried* soil can take up when saturated is approximately as follows :—

Sandy soil	2·25 pounds.
Light loam	3·04 pounds.
Medium loam	3·22 pounds.
Heavy loam	3·32 pounds.
Clay soil	3·85 pounds.

If, in the cold weather, the subsoil between two and three feet deep contains more than one-third of this amount (or perhaps one-half with a sandy or light soil) calculated on the dried soil, it will be most probably waterlogged in the rains, and needs subsoil drainage badly. The next test can be still more easily applied by digging a hole in the land after rain has been steadily falling for some days at the height of the monsoon. If, at this time, the water is within three or even four feet of the surface, a case for immediate deep drainage has been made out. A still further test depends on the rapidity with which the water falling on the surface disappears into the land. Observation on this point is only valuable after there has been much rain for some days, and the soil is thoroughly wet. In any case two hours after the rain ceases, the surface should be free from standing water.

If the land answers satisfactorily the tests above set down, I think that it may be concluded that the cause of the deterioration lies elsewhere than in the drainage ; if not, systematic draining must be undertaken. It would lead us too far to go here into the methods by which the drainage must be done, and for this I must refer the reader to the chapter on the drainage of tea gardens in "The Pests and Blights of the Tea Plant" (second edition), by Sir George Watt and the writer, published in 1903.

PHYSICAL CONDITION OF THE SOIL.

But if the drainage is satisfactory, is the physical condition of the soil and subsoil as it should be ? In other words, is the soil in good 'tilth' not merely on the surface, but for some distance into the land as well ? If not, is the nature of the soil to blame, or is the condition solely due to lack of adequate cultivation ? The first test to be applied in this connection is the pressing of a stick down into the land. It will most likely be easily forced in to the depth of four to six inches in any garden, but in one where the soil conditions are good there should be no trouble in driving it by pressure of the hands alone to eight or ten inches, and sometimes even to fifteen inches deep. If such a stick shows evidence of a hard layer (otherwise a 'hard pan') at a depth of less than ten to twelve inches, it is evident that

the condition of the soil needs improvement. A second test is furnished by the condition of the roots themselves. If they are flattened out, if all the rootlets which tend downward become rapidly small and stunted, if the whole root development is a surface one, this affords a strong reason for supposing that the subsoil conditions need improvement in a physical sense.*

The soil improvement needed may be merely more and better light hoeing. In quite a number of tea estates, in the Duars for instance, which have come under my notice and where the tea is said to be 'going back,' this is almost certainly the case. The precise cause of the effect which this light cultivation produces on the bushes has never been entirely explained. Its primary object is, of course, always held to be the burial and destruction of jungle growth. But it must do more than this, for, in places as we have noted above, where jungle growth is very small, the effect of lack of cultivation is equally obvious in a rapid yellowing of the bushes and a speedy increase in disease. In a large measure, no doubt, the cultivation is useful because it keeps the surface soil loose, and allows the tea rootlets thus easily to push through it. There is, we fancy, something even beyond this. In heavy soils, at any rate, there is always a large amount of plant food in the soil that no plant can use, as it is not in a condition in which it is absorbable by vegetable growth. This becomes only gradually available in the soil when it is exposed to atmospheric influences. A large quantity of the phosphoric acid and potash in heavy soils is usually in this unavailable condition, and it needs the exposure caused by the regular hoeing to make them ready to be absorbed by plant life. This is the more probable, because as land gets older and longer under tea, cultivation becomes more and more necessary to maintain vigour in the bushes, and a garden which will in its early days do well with four light hoes per annum, will ten years later need six or seven to give anything like equal results.

While on this point I cannot refrain from referring to a controversy which has recently arisen as to the value of hoeing a garden in the latter part of a season, say from August onwards † My own idea is that such cultivation is extremely valuable, and this largely from considerations not of the results for the season in which it is done, but rather of the following one. It may generally, I think, be said that any lack of hoeing in the latter part of one year is likely to be felt in poor thin weedy growth at the beginning of the following season.

---

* This argument hardly applies to tea planted on peat bheels, for the root development is there always a surface one.

† In some Duars gardens little hoeing is done after June. The above remarks apply still more strongly to such cases.

Quite as often as it is the result of deficient light hoeing, the deterioration in the tea is directly caused by poor shallow cold weather cultivation, or by this cultivation being done very late. One can hardly too strongly insist on the importance of the cold weather deep hoeing. If done deep enough, it makes the lower layers of the soil friable, and hence penetrable by the delicate tea roots. It causes the retention of a large quantity of moisture during the dry season in the subsoil for the use of the plant, which would otherwise be lost. Very frequently indeed the non-luxuriance of a tea estate can be traced to scamping of the cold weather deep hoe or to its being left too late.

While adequate cultivation can be obtained by hoeing of various kinds, this does not make the deeper subsoil friable and penetrable for the tea roots as it should be. This can only be done by growing deep-rooted trees and plants in among the tea. To this subject we will return a little later in dealing with green manuring.

EXHAUSTION OF PLANT FOOD.

But the land may be well drained and cultivated, it may be in good physical condition to a sufficient depth, yet if it is exhausted of plant food, these will count for little, and manuring in one form or another will be essential. This stage has been reached in many Assam gardens, and can be judged on the spot fairly well by several indications. The first of these is the character of the weed herbage. Wherever, for instance, '*ilami*' '*cold weather weed*' (*Ageratum sp.*) grows vigorously, the soil is not exhausted ; and the same may be said of quite a number of the common weeds of tea. A short, stunted herbage, principally of small grasses, on the other hand always looks bad, and seems to indicate exhausted land. A little examination of the jungle on good land and on the old areas of a garden will very quickly show the difference in the character of the weeds on which I wish to insist. A second and excellent test of the exhaustion or otherwise of a tea soil is obtained by trying to grow *mati kalai* (*Phaseolus mungo*) upon it. If this be put into well hoed, slightly moist land, at the end of April or the early part of May, and it is not ruined by very heavy rain, the vigour of its growth may be taken as a very fair measure of the condition of the soil in this respect. If it flourishes and grows two feet high or more in six or seven weeks, the soil is good enough for the time being ; if not, it is probable that manure is required before the tea will reach what it ought to be. A third indication of the exhaustion of the surface soil is given by a gradually increasing difficulty in retaining good tilth on the surface of the land. The condition of the soil largely depends on the amount of organic

matter present, and when this disappears through long growth of a crop, the tilth suffers, and the surface after hoeing often quickly forms a hard-baked layer of soil again.

The last and ultimate test of exhaustion is analysis of the soil. It is necessary to urge tea growers, however, not to depend too much on the indications which this gives, for soil analysis even in its most modern developments is essentially a very clumsy means of finding out the real richness of the land. But if all the indications above named give results tending to show that the soil is exhausted, it will probably be wise to have the soil examined by a chemist, in order to determine the most economical way of applying the manures which they have shown to be necessary.

Limits of space do not allow me here to go into the question of the manures adapted to special soils and special conditions. Suffice it to say that where the principal deterioration is in luxuriance, there the more important manure constituents will usually be organic matter and nitrogen, and these can best be supplied by top-dressing with good *bheel* soil, if available, by cattle manure, by oil cake, or by green manures. If deterioration in quality is chiefly to be treated, manures containing phosphates appear of the greatest importance. There is one class of manure whose effect has proved very great under many conditions, and the application of which costs very little—I mean green manures.

GREEN MANURES.

First and foremost of these in the Indian districts come the leguminous trees, of which the *sau* (*Albizzia stipulata*) is the chief. They not only manure the soil by their leaves and roots, but also improve the condition of the land in which they grow. Their effect is little seen during the first three years or so of their life, but as they become mature they produce a dark healthy colour on the tea all round them which is quite different from the remainder of the blocks in which they are planted. The best practice places them sixty feet apart throughout the tea and keeps them well lopped so that they do not overhang the tea bushes.

In the second order come the leguminous bushes, of which the only one hitherto tried on an extended scale is the *boga medeloa* (*Tephrosia candida*) which has given excellent results both in Assam and Sylhet. A few seeds, generally 3 or 4, are planted on a small heap between alternate bushes in alternate rows in April or May, and protected from the hoeing coolies by a tripod of three sticks. By the end of the season the plants are seven or eight feet high, and from this time the whole should be kept trimmed to a narrow shape, and everything that is pruned off buried with the hoeing.

This trimming should be done four or five times every year, and may well be done before every round of hoeing, and the material be buried with the hoe. The bush should be kept so that it does not interfere with the pluckers, nor materially shade the tea. At the end of three years the whole plants are pulled up, and buried in trenches between the rows of tea. This method has, as has already been said, given good results on light land, and the increased vigour in old and deteriorated tea has quickly shown itself in the yield, as well as in the appearance of the bushes. The *boga medeloa* has the special advantage of growing in very poor light soils, such as would not grow any crop of almost all the other green manures which have been tried.

In the third rank of green manures stand the annual crops which are grown for a short time on the land and then hoed in as a whole. In India, very great results have already been obtained by the use of *mati kalai* (*Phaseolus mungo*), which is sown broadcast on the land at the end of April or the early part of May and hoed in at the latter part of June or the early part of July. It is found unwise to allow it to remain on the land more than about eight weeks. During 1905, equally good results have been obtained on an experimental scale with two other plants, *Crotolaria striata* (the crop principally used for this purpose in Ceylon) and *dhaincha* (*Sesbania cannabina*), a common crop of Lower Bengal. Each of these remains on the land eight to ten weeks, and is then hoed into the soil. The effect seems partially due to the considerable improvement which they always effect in the texture of the land, and partly to the very large amount of nitrogen which they take up from the air by means of their root nodules, and so make it available as plant food for the tea. The trouble with each of them is that they will not grow on very highly exhausted soils, and in such cases demand a small quantity of cattle manure (say two tons per acre) to give them a start, after which they will grow luxuriantly.

DETERIORATION OF THE TEA PLANTS

We have dealt with the methods by which deterioration of tea due to defective soil conditions or to soil exhaustion may be treated. We cannot too much insist that in any case of manifest decline the soil should be the first thing looked to, and heavy or collar pruning of the bush only adopted after becoming sure that the fundamental mischief does not lie in the exhaustion of the land. But if this is certain, then the bush itself should be examined, and the cause of the decline most probably will be found there. The causes of the deterioration of a tea bush seem to be inseparable from the method of culture. When a tree, usually eighteen to twenty feet high, is kept down to four feet as a limit ; when every green shoot which it throws

out is nipped off more or less closely ; when the annual pruning on the youngest grown wood renders the course of the sap in the plant continually longer and more circuitous ; it is only natural that sooner or later (the time depending on the vigour of the bush, and this on the richness of the land), the plant will begin to decline in yield, that the younger shoots will become less energetic in throwing out new leaves, and that the tea will begin to deteriorate.

The result obtained is in accordance with this expectation, but there are methods of culture which hasten the day of decline, and which have made many gardens begin to 'go off' before the time they need have done. The earliest and still the most frequent of these is probably too hard plucking in the early part of the season. It is well known and well recognised that if a bush is to continue healthy and yielding, great care must be taken with the first and second series of shoots in the year, but, even yet, I am confident that anxiety to make tea in May and June is at the bottom of the rapid decline of many a good garden. The growth which is allowed to remain on the bush immediately after pruning is left for three reasons. First, in order to provide wood for pruning, in the next year ; second, to give the bush enough leaf growth to keep it well supplied with breathing organs during the season ; and third, to afford plenty of leaf axils from which the secondary shoots or 'flushes' may arise. To provide for the second of these purposes far more growth is necessary than would be required to supply the first and third, and it is due to the non-recognition of this fact that the early pluckings have often been too close, and numerous evil results have followed and are following. In the later part of the season when there is amply sufficient leaf growth to feed the bush, the young shoots may be plucked absolutely close as they grow, but to do so (in North-East India) even under the most favourable conditions of growth till the beginning of July, is a policy which, though it may apparently do well on a young and flourishing garden for some years, will quickly bring about a serious decline in the value of the bushes.

The second principal hastening cause in the deterioration of tea bushes is incorrect pruning. The subject is too long a one to deal with here in full.* It may be said, however, that in the past damage has been done both by cutting too little out of the bushes, and in a less measure, by cutting too much. The following points should, however, be noticed in pruning, and even if the process then costs more than it has usually been the habit to spend, the

* For a consideration of the principles underlying tea pruning see Chapter VI of "The Pests and Blights of Tea Plant," by Watt and Mann, 1903.

extra amount is well invested if the decline of the bushes is, by this means, delayed :—

(*a*) All dead branches should be removed.

(*b*) All gnarled twigs and 'crow's-foot' clumps of imperfectly formed shoots (otherwise, the previous year's *banjhi* flushing) should be taken out.

(*c*) All snags, which are seen to have little chance of healing over, might well be pruned off.

(*d*) All "trailing" branches at the outside of the bush are better away.

(*e*) All the previous year's horizontal shoots at the outside of the bushes should be headed back to induce them to throw out vertical shoots.

(*f*) All small twiggy shoots throughout the bushes, which will never give strong healthy wood for the next year, should be cut right back to the stem from which they arise.

(*g*) The amount of new wood left on each shoot should be as little as possible (generally not more than one and a half inches), consistent with this containing one bud, dormant or otherwise.

(*h*) The same length of new wood should be left on each pruned shoot throughout the bush.

Where deterioration of the bush has commenced, either in the normal course or hastened by incorrect pruning or plucking, there is one method of bringing it back to a healthy condition, provided always that the soil and the roots are in a thoroughly satisfactory condition. This is by 'heavy pruning.' Though more rational methods of annual light pruning will make heavy pruning necessary less often than it would be otherwise, and less often than it has been in the past, yet just as pruning at all is necessary to remove the refuse mass of twigs which plucking, say twenty to thirty times in the season, leaves in the bush, so heavy pruning is necessary to remove the refuse of several light prunings. But it is not merely a method of removing the refuse non-yielding wood from a bush ; it also has an effect in directly stimulating the plant to greater exertions, and this is evidenced, if by nothing else, by the greater development of small-feeding rootlets after heavy cutting of the plant, provided the soil is such as to allow of their formation. This is probably one of the principal reasons in some cases why heavy and especially collar pruning has been such a great success. The bushes are a mass of useless wood, inadequate feeding of the root energies occurs, and little new root growth takes place. The bush is heavily pruned or even collar pruned, and allowed to rest, when the whole of the new growth spends its time in feeding roots innumerable ; new and valuable rootlets make their appearance, and the result is a magnificent bush, which, if dealt with properly, gives as good a plant probably as has ever been in the place before.

The amount of pruning required to stay deterioration is a matter which can only be settled by a practical man on the spot. There are, however, several general guiding principles. In the first place, heavy pruning should not disturb, if possible, the shape and framework of the bush, and if it is necessary to cut so low down that this is destroyed, collar pruning is indicated. Secondly, as few knots as possible should be left below the cutting. Again, grey lichenous growths on a bush are a sign that the wood on which they are taking place must be cut out * if it cannot be made vigorous by heavy manuring. Fourthly, it seems that in almost every case manure should be applied either before or at the time of heavy pruning, at any rate if the pruning is really low. It will stimulate the bush at a time when it has suffered a great shock and so should usually be given even on a good soil. Finally, the bush must be nursed and easily treated for a long time after the heavy or collar pruning is carried out, and in very low cutting it requires very careful cultivation, especially immediately round the stem of the bush.

TREATMENT OF VERY BAD TEA.

There may come a time in any garden, and it has already come in a few gardens in the older portions of Assam, where the methods hitherto mentioned seem insufficient to bring deteriorated tea back to a profitable and yielding basis. The bushes have been collar pruned and heavy pruned until there is no opportunity for further work in this direction. Manure has been applied, but the result has not been profitable. Under these conditions what is to be done? Until recently the only answer has been to abandon the tea altogether. Objectionable as this may be, in some cases it is perhaps still the only policy, but experiments have been initiated in another direction during the last three or four years which will perhaps result in bringing back tea to a profitable condition which would otherwise fall out altogether.

Essentially the process is this. The bush is heavy pruned again, cutting wherever reasonably good wood can be obtained, the block is manured with say fifteen maunds of oilcake per acre or an equivalent amount of cattle manure, and then the whole is left absolutely unplucked either throughout the whole season or until August, September or even October, receiving its full share of cultivation, however, the whole time. Under these circumstances bushes often produce thicker wood than they have done for many years, which can form a basis for future growth. Whether the rejuvenation of the bushes will be permanent is a matter for time to decide. The whole question is still in the experimental stage, but there seems a likelihood that

* This is not quite the case in hill districts where lichen and moss are much commoner than elsewhere.

by this means tea, which would otherwise have to be abandoned, may be again made useful and profitable.

CONCLUSION.

We have now dealt with the signs of deterioration, its causes, and the methods which seem best adapted for bringing back to a profitable condition much of the tea in India which has now declined from its former value. While much of the deterioration which has taken place in the past has been natural and the result of age, very much more has been the result of unwise treatment of either the soil or the plants. In conclusion, it must be urged very strongly that in the matter of dealing with tea, prevention of deterioration is very much better than any cure. A little money spent in draining, in manuring, in cultivation, in more careful pruning, or a little less feverish anxiety to take the last farthing out of the bushes in the way of yield (more especially in the earlier part of the season), will often prevent a crisis such as has frequently occurred in the history of so many tea concerns. To this aspect of the question I would most earnestly draw the attention of those gardens now in a flourishing condition, while the methods I have here suggested may well be applied by those in the less happy position of holding in their properties already deteriorated tea.

MOTHBORER IN SUGARCANE, MAIZE AND SORGHUM IN WESTERN INDIA.

By H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.

Entomologist to the Government of India.

WHEREVER sugarcane is grown as a staple crop, it is infested with the caterpillars of moths, known under the general name of "Mothborer." These insects belong to a large family of moths, *Pyralidæ*, and fall chiefly in one subfamily—the Grassmoths or *Crambidæ*.

In different parts of the world, different species occur, and though these are to some extent spread over large areas, those of the East are in the main distinct from those of the West. Java has several species not as yet known in India, nor is the common mothborer of the West Indies, *Diatræa saccharalis*, definitely known in India, though it is recorded in Ceylon.

The mothborers of India are of several species ; the one discussed in these pages, *Chilo simplex*, is certainly the only species widely spread as a pest in Western India. Quite recently it has been found that one of the mothborers of Bengal is *Chilo auricilia*, a species extremely easily confused with *C. simplex*. Though the latter is stated to be the common mothborer of all India, this statement may now be taken with caution, and until more is known of the mothborers of different places, the identity of the particular species is better left in doubt. In addition to the *Chilo*, there are such borers as *Scirpophaga auriflua*, *S. excerptalis*, *Nonagria uniformis* etc. While these do not occur commonly in Western India, they are known in Bengal and their range is a matter of doubt. It has, therefore, been thought best to entitle *Chilo simplex* the mothborer of Western India, with the reservation that it may prove to be the most common mothborer of Bengal, Madras, the United Provinces, Punjab, etc.

Years of work will be required to ascertain the range of the various species, and the mothborers of cane in Bengal should be investigated and worked out as the next step in this enquiry. It may be pointed out that though the difference between *Chilo simplex* and *Chilo auricilia* may be one

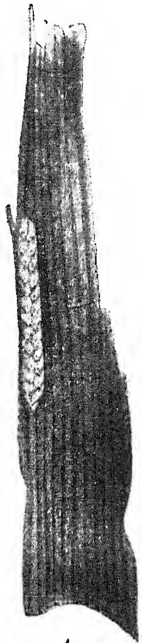
that appeals only to Entomologists, the differences in their habits may be so great as to make the treatment of each quite distinct. The differences between *Chilo simplex* and *Diatrœa saccharalis* are small, but the best remedy for the latter is useless for the former, so that the conclusions arrived at from a study of *Chilo simplex* in Western India cannot be applied offhand to similar insects in other parts of India. It will be necessary to obtain larvæ and rear them for determination. When it is known what species occurs in each province, the remedies for the proper insect can be applied.

LIFE HISTORY IN SUGARCANE.

(*A.*) *Eggs.* The eggs (Plate X, fig. 1) are laid by the moth in clusters on the leaves. Each egg is oval, flattened, about one millimetre long; the upper surface is very finely marked and is not flat but slightly convex. The eggs overlap, in two rows as a rule, (Plate X, fig. 2) and give the appearance of nearly flat oval cakes of dough laid down one after another in two rows. The whole cluster is fastened to the leaf, sticking to it. The number of eggs forming each cluster is very variable; as a rule it lies between 10 and 30, the average being about 14. In young canes the egg clusters are found nearer the top or on the centre leaves that stand straight up. The upper side is the most usual and near the mid-rib or on it, but there is no great regularity in this. The eggs when first laid are a dull creamy white; this colour lasts for some period and towards the time for hatching the eggs turn orange and a black spot appears in the middle. The caterpillar can be seen curled up inside, the black head in the middle. It has only to bite through the thin shell and emerge. The empty egg-shell is white. In canes that are forming "joints" and in ripe canes, the eggs are laid on the leaves, usually on the apical half on the upper surface. It is not easy to find eggs on old canes owing to the great leaf expanse to be examined, nor is it always easy to see eggs on young canes. The colour is so inconspicuous, the size so small, and the clusters so like the spots, splashes of excreta and the like on cane leaves, that the eggs very readily escape notice.

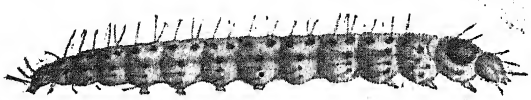
Black eggs. It is not unusual to find that a proportion of the eggs are of a deep brown or black colour. These eggs contain parasites, which feed upon the substance of the egg and then make a tiny round hole in the centre of the egg for emergence. Such eggs may be found before and after the parasite has emerged; the proportion of black eggs to normal eggs may be very large, as much as 75 per cent; also as the black eggs that have hatched stay on the leaf, whilst normal eggs that hatch (and which are white) soon fall off and are not found, one may find large numbers of black eggs from which the parasites have emerged. There are, therefore, five kinds

PLATE X.

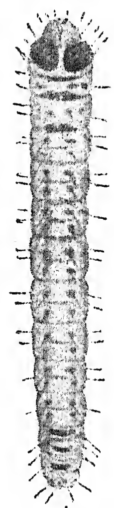


1.

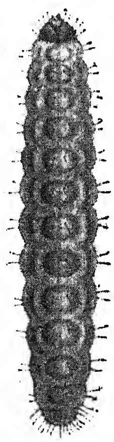
2.



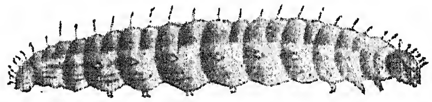
3.



4.



5.



6.

Mothborer in Sugarcane.

AJI

of egg clusters: (1) Light yellow eggs, freshly laid. (2) Orange coloured eggs, which will soon hatch caterpillars. (3) White eggs, eggs from which caterpillars have hatched. (4) Black eggs, whole, which contain parasites. (5) Black eggs with a small puncture, from which the parasite has escaped.

(*B.*) *Caterpillars.*—The caterpillar as it emerges from the egg is a tiny worm-like creature, some two millimetres in length, of an orange colour with black head. The body is slender, the head large; there are bands of deeper colour round each segment and small dark hairs that give it a spiny appearance. It walks actively about the plant, sometimes letting itself down by a thread from the edge of the leaf. The epidermis of the leaf is eaten in little spots, and the caterpillar often burrows into the mid-rib and tunnels down towards the centre. In a short time it reaches the heart of the shoot and lives in the outer leaves for some days. Cane shoots are often found with small patches of epidermis eaten off, fine dust lying on the centre leaves and a general appearance of having been eaten by caterpillars; this is due to the newly hatched caterpillars and a sure sign of the recent hatching of an egg-cluster.

After the caterpillar has become larger ($\frac{1}{4}$-inch long) it tunnels into the heart of the cane and feeds on the rolled up centre leaves or the growing point of the stem. As a rule only one large caterpillar is found in each shoot; the others leave the shoot and attack separate shoots. The centre leaves are cut through and die; as they wither the dead shoots are readily seen and in such shoots (called "dead hearts") the caterpillar can be found. If the shoots are small, one caterpillar will eat several, eating its way in and out of each at the base, at the level of the ground. If the shoots are large, one caterpillar will find sufficient food for its whole life, and there may be two in one shoot. Whenever the growing point is eaten the shoot dies. In older canes, the caterpillar tunnels in the joints and does not necessarily destroy the growing point and kill the shoot; as soon as joints begin to form, the "dead heart" is not seen and fewer borers are found. The borer is seldom found in the ripening cane to any extent; it leaves the canes after the joints form and then prefers other crops.

The full grown caterpillar (Plate X., figs. 3-4) is one inch long, the head black or dark brown, the body dirty white. There is a conspicuous dark patch behind the head, and as a rule two lines of dark colour running down the body from head to tail on each side. On each segment there are small spines or hairs set on dark spots; the usual three pairs of jointed legs and five pairs of sucker feet are present.

The actual colour of the caterpillar is extremely variable. A caterpillar living in a cane shoot and feeding actively has the black spots on each

segment well marked ; as it becomes full-fed, purple brown pigment is found in the tissues, showing as a longitudinal line of colour on each side. When resting prior to pupation, the colour may entirely disappear. Hibernating larvæ frequently show no spots, the colour of the hairs and spots being the same dirty white as that of the skin ; the purple brown pigment may be largely developed, not in longitudinal lines but in curved lines in each segment. (Plate X., figs. 5-6.)

It is difficult to be certain of the identification of the larvæ of the mothborer ; it is closely similar to the larva of the *Nonagria* that lives in wheat and juari ; it also resembles closely the borer in brinjal stems, (*Solanum melongena*) several borers in paddy, &c. Microscopic examination of the mouth parts, spiracles, hairs, and the like, is necessary to differentiate these larvæ, and the best plan is to rear the larva in captivity until the moth emerges.

The caterpillar can produce silk and uses it chiefly for preparing the burrow for pupation. Sometimes the whole burrow is lined with closely woven silk ; often the caterpillar lies in a long tube of silk and dust. The duration of the caterpillar stage is exceedingly variable ; in hot weather in young cane the larva is full fed in about four weeks ; during the winter in dry sorghum stalks the caterpillar hibernates and this period may last from six to eight months. It is not hibernation proper, that is, it is not dependent on temperature, since a part of this period (March to May) is in the hot weather. Probably the duration of the larval life is simply a matter of food, moisture and season. The caterpillar can pass to the pupa stage four weeks after hatching : it can rest as a full-grown insect for six months or longer if it wishes to or if the conditions render it necessary.

(*C.*) *The Chrysalis.*—At the end of two days' quiescence, the caterpillar sheds its skin and appears as a small brown chrysalis. (Plate XI., fig. 1.) The male chrysalis is smaller ($\frac{1}{2}$-inch) than that of the female ($\frac{3}{4}$-inch), though both are otherwise identical in appearance. The chrysalis remains motionless in the burrow, with its head to the opening ; it can make convulsive movements with its abdomen but has no means of locomotion, and during this period of quiescence the tissues of the moth are built up from the tissues of the caterpillar. At the end of six days the male moth emerges, the chrysalis skin breaking open in front to allow the moth to escape. The female chrysalis requires one day longer, in some cases two. This is the usual period when the weather is warm or during the rains ; chrysalides are sometimes found during the cold weather with hibernating larvæ, and the insect evidently can hibernate as a chrysalis. In this case the chrysalis period may be very long, but apparently when the insect hibernates as a chrysalis, it emerges

as a moth when the weather becomes hot. In this case it is true hibernation dependent upon temperature; the larvæ that hibernate can remain as dormant larvæ during the hot weather succeeding the winter, the pupæ apparently cannot.

(*D.*) *The Moth.*—The moth is a small yellowish grey insect with prominent palpi projecting in front of the head like a beak; its appearance is best realised from an examination of the figures on Plate XI. The male is distinctly smaller than the female and is frequently darker in appearance; the hind wing is also slightly darkened, and not, as in the female, white. The wings when spread measure nearly one inch across. In repose the wings are laid on the back, one overlapping the other, as if wrapped round the abdomen.

The moths fly in the dusk and at night. During the daytime they hide among the leaves or on the ground and come out as dusk falls. In captivity they are not long lived, a week being usually the longest period; it is probable that being unable to feed (the proboscis being absent) they live only long enough to mate and lay eggs, the male dying after mating, the female after all the eggs are deposited. It would be interesting to know if the moths can remain dormant when there are no plants on which to lay eggs; moths emerging during the hot weather before the rains may not find any food-plants and it seems likely that they can remain dormant probably in the ground until the rains bring fresh crops.

FOOD PLANTS.

In addition to cane, this insect has been found in maize (*Zea mais*) and juari (*Andropogon sorghum*), and rarely in bajri (*Pennisetum typhoideum*).

In cane it principally attacks the young shoots, but can attack the stem at any stage of growth. In maize, besides the young plants, it attacks the stem, the cob and the tassel; the succulent stems are often riddled through by the tunnels of these caterpillars; the young caterpillars feed on the leaves and then pass down to attack the stem. The tassel is sometimes eaten up by them; great numbers especially young ones may be found, and they like to feed on the tassel before burrowing into the stem. The cob is also eaten, the worm eating through the sheathing leaves and burrowing in the cob or simply eating the grain. In sorghum, the young plants are attacked and also the stems of older ones. In all stages of growth the stem is attacked and as a rule the grain is untouched. The following is quoted from the report of the Cawnpore Farm for 1901-1902:—

"This borer is not the only one, but that which about here apparently does most damage to sugarcane, maize and juari. Last year the sugarcane

was attacked in the early stage, destroying the young shoots. As the plants grew stronger no further damage was observed, and I was unable to find any outward signs of the borer during the rest of the sugarcane's growth, though larvæ were found in the tops at crushing time. This year the young shoots have again been attacked in a similar manner. The juari plants appear to be nearly all more or less attacked at some time of life, but it does not appear to affect their growth and production of grain very much. The maize plants are attacked when young, in some cases killing the plant and in others injuring its growth. The larvæ pupate in the stalk or inside the leaf sheath and the second generation appears to attack the plant higher up, the larvæ entering the stalk a little below the cob, and in many cases the cobs were injured by the larvæ eating a passage through the grains along the face of the cob and finally pupating there. There appears to be no difficulty in transferring these borers from one of these three plants to the other." (J. M. Hayman.)

DAMAGE.

In Cane.—Mothborer is chiefly injurious to canes in the young stage before any cane joints are formed. From the time that the shoots are well out of the ground, the caterpillars feed in them and every shoot bored dies. There may be a very heavy loss of shoots, in some cases a practically total loss of the first growth. New shoots are formed and such of these as escape grow up to form canes. The result of this form of attack is a more or less serious retardation of the growth of the plant, in some cases amounting to a total destruction of a percentage of the crop. Up to five months after planting this form of loss continues. When joints are formed, the mothborer lives in the joints and does not cause the death of the cane shoots. There is a reduction in the yield of sugar from the damage done in the ripening cane by the caterpillar, but no serious case of this has been found during the past seasons, the borer being only destructive to cane in the first five months.

In Sorghum.—Juari is attacked in all stages ; young plants are attacked in the same way as are cane plants ; older plants are very much infested with the caterpillars, the stalks being tunnelled and the plant often so weakened that it is blown down and dies. This leads to the weakening or death of the plant ; no case seen has been serious, though a case of large damage to juari is reported from Sind.

In Maize.—In this crop the insect attacks every part of the plant above ground, the most serious damage being to the cob. The young plants are attacked and killed, as in the case of cane ; the stems of older plants are riddled ; the tassel and the developing cob may be full of caterpillars, in the

latter case the grain being eaten and the cob rendered valueless. In this crop there is material direct injury to the valuable grain, and the injury is likely to be of great importance.

ENEMIES.

The eggs are parasitized by a minute parasite (*Penarthron indicæ* Ashm.) one of the minute Hymenoptera which lay their eggs in the eggs of other insects. Eggs which contain parasites turn a dark colour and become black ; a minute hole is then made and the tiny flying insects emerge from the egg. They are so small that they escape notice and can only be seen by the aid of a good magnifying glass. To what extent they regularly occur is not known, a varying percentage of the eggs found yielding parasites. This percentage varies from about ten to over eighty per cent. and depends upon the length of time the borer has been laying eggs, the number of eggs laid, and the like.

The caterpillars are preyed upon by a black beetle grub (*Carabidæ*) which runs actively about seeking the larvæ, which it sucks out. This insect apparently preys upon the caterpillar while it is exposed, as on the tassel and cob of Indian corn. It has not been found attacking mothborer caterpillars in other crops and probably cannot reach them in their burrows. All attempts to rear this larva failed. A chalcid parasite, *Cotesia flavipes*, Cam. (Plate XI., fig. 5), has been recorded as attacking the mothborer in juari (Indian Museum Notes, Vol. I., p. 28). An undetermined Tachinid fly (No. 119) has also been reared from the caterpillars.

On splitting open a cane shoot attacked by mothborer, one commonly finds the discoloured centre evidently decaying and emitting an offensive odour. When the borer cuts through the base of the rolled-up centre leaves, these die and decay. Two-winged flies (Diptera) then lay their eggs, and the shoot becomes infested with small white maggots. These are not parasites nor are they destructive to the cane. They are purely saprophytic, living on the decaying vegetable matter as so many flies do. Such maggots are very commonly found in decaying tissues. When full grown, these maggots turn to little brown pupæ in the cane, and one may find these with younger maggots. Such maggots are of no importance and may be neglected.

HABITS THROUGHOUT THE YEAR.

The mothborer is equally at home in cane, maize and sorghum, and so has a succession of crops throughout the year on which to feed. If either of these crops was grown throughout the year, the mothborer would be able to live and feed actively so long as warm weather continued. Where some of these

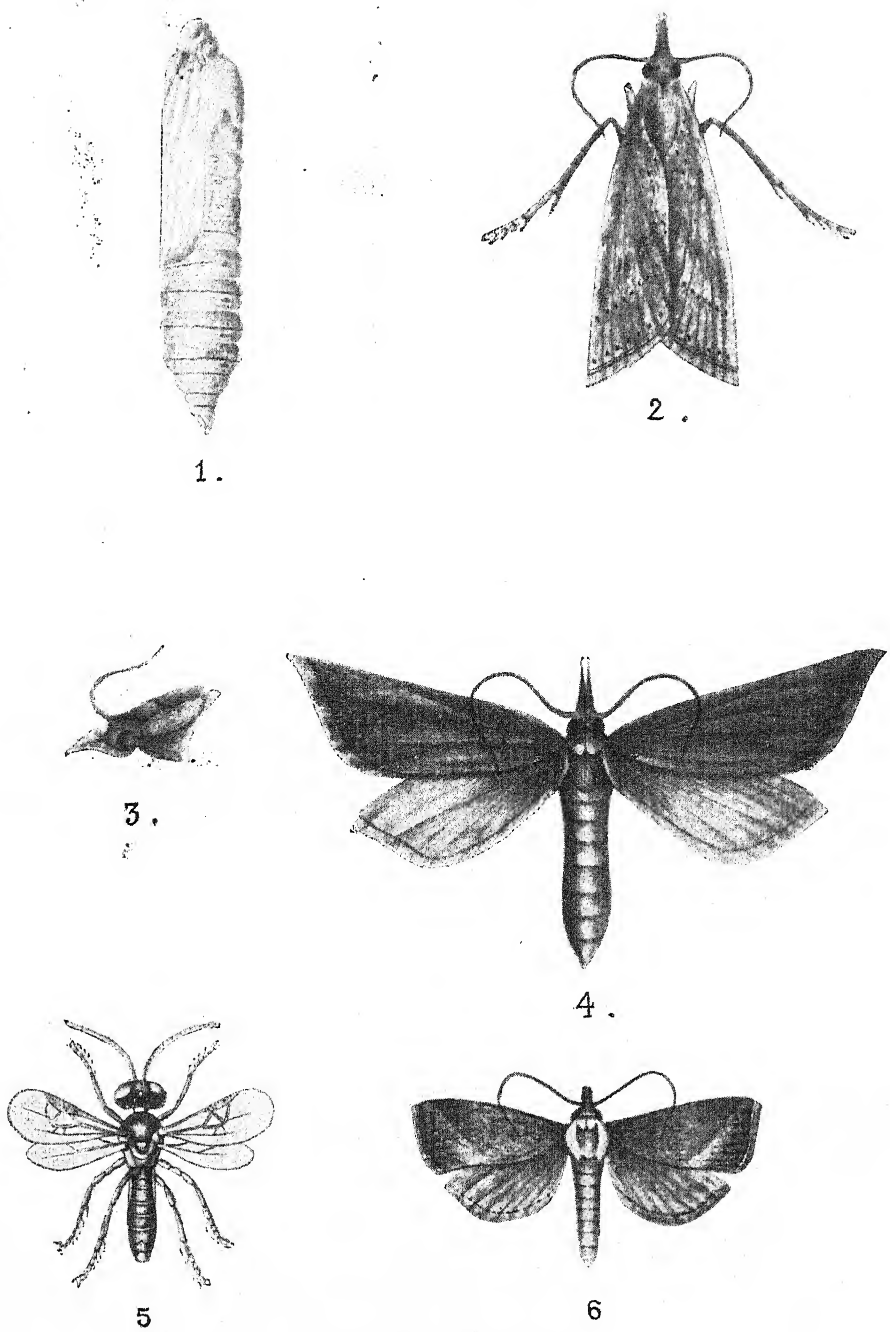
crops are grown irregularly, the borer has to find a succession of food plants, and should the winter be sufficiently cold, it has to cease feeding and hibernate. There are then two periods when its activities may have to cease, owing to climate or lack of food.

In South Gujarat, the habits of the borer have been found to be as follows: During the growth of the *kharif* crops, it feeds in sorghum or maize indiscriminately, chiefly in sorghum where that is the staple crop. From July or August to October, there was a succession of insects in these two crops. In November, the larvæ in the sorghum hibernate; they are then in the dry stalks, stacked for fodder, or in the stubble, and may be found in great numbers from November to May. During December to March, where young canes are coming up, a proportion of the larvæ pupate and emerge as moths and lay eggs in the canes. From January onwards the young cane is infested with borers, though a great number of hibernating larvæ are still to be found in the sorghum. Apparently all these hibernating larvæ in sorghum emerge as moths by June and attack the cane if there is cane in the district. They live in these canes till the sorghum or maize is up and large enough to give them food. In short, the caterpillars hibernate from November onwards in sorghum, attack cane and gradually all hatch till May, feed on cane till July or August, and remain in the sorghum and maize till hibernation. This is the sequence observed in the Surat District, but it must be remembered that this sequence is by no means invariable. Some moths hatch out at different times and lay eggs, for instance, on ripe canes (left for seed) in January to February, as well as in the young canes. The number that hatch early in March is only a proportion of the whole number. Apparently there is great variation in this respect; it would not seem likely that all have definite habits, and probably a moth, hatching in March and finding no green plants on which to lay eggs, can remain hidden in the ground or elsewhere till the rains bring a fresh supply of food. The obvious fact is that any irrigated crop, cane or sorghum, will be attacked during the months of January to June.

At Manjri near Poona, the sequence is much the same, varied only by the difference in the crops there. Irrigated sorghum may be grown from March onwards and the insect finds sorghum as well as old or young canes from March to July. At places in the Konkan where cane was growing during December, February and March, the borer was found attacking it.

With regard to the food plants mothborer prefers young sorghum to young cane; young sorghum plants growing with young canes will be infested when the canes are not. Mature canes are least attacked; ripening sorghum is attacked in preference to ripening cane; ripening maize is attacked in preference to young sorghum. The conclusions arrived at are

PLATE XI.



Mothborer in Sugarcane.

A J I

(1) Mothborer attacks young canes but will not remain in cane after it commences to form joints, if sorghum or corn is available (up to five months from planting) ; (2) it readily attacks young sorghum, in preference to young cane, and its chief food plant is sorghum ; (3) it attacks maize when in flower or when the cob is forming in preference to sorghum ; (4) it can remain dormant as a caterpillar from the time the sorghum ripens till the rains fall in June or July ; when irrigated cane or sorghum is available it may attack it at any time from December to June ; (5) when no irrigated crop is available, hibernating larvæ hatch at any time from March to June, and probably moths can live in a dormant state till fresh crops are up ; (6) the sequence observed will vary largely with the climate, and the crops which are available during the dry season.

Broods.—There are no regular broods of this pest in the sense of large numbers of insects of the same age occurring together ; the eggs of any large number of females are not laid simultaneously, so as to give rise to a definite brood. At any time, insects of all stages may be found in the same field. This is due to the conditions under which the moths emerge and lay eggs, emergence being gradual during the first five months of the year.

The number of generations in one year will vary with local conditions. Were there no resting period, there would be from eight to ten generations in one year from each female laying eggs at the commencement of the year ; as it is there would be four generations from June to October, and then from one to five during the ensuing dry cold and hot weather, depending on the time at which the moth hatched and the presence of irrigated crops such as cane on which the caterpillars could feed.

DISTRIBUTION.

The accounts in Indian Museum Notes, Vol. V., p. 169, give a complete bibliography of this mothborer, and also the synonyms and references to the descriptions. The geographical distribution as there stated is Japan, Formosa, Chusan, Punjab, Karachi, Poona, Mhow, Khandalla. The references in Indian Museum Notes and specimens since received or collected show that the insect is widely spread over the plains. Bombay Presidency, Sind, the Punjab, United Provinces, Bengal, Central Provinces are all represented. South India is apparently an uncertain locality and the borers of sorghum in that tract may be *Chilo simplex* or some other species. The bibliography of the West Indian Mothborer, *Diatræa saccharalis*, is compiled up to 1900 in the West Indian Bulletin, Vol. I., p. 351, and this is a fairly complete bibliography of all sugarcane borers.

The recent discovery that *Chilo simplex* is not the common borer of one district in Bengal but is there replaced by *Chilo auricilia* must be taken into account. It is impossible to be certain that *Chilo auricilia* was not frequently identified as *Chilo simplex* or as *Diatræa saccharalis;* the most competent entomologist, who was not a specilist in moths, would be deceived by the likeness and would have no reason to suspect a closely allied species. The writer on seeing the specimens of *Chilo auricilia* assigned them to *Chilo simplex*, until the distinction was pointed out by Mr. G. C. Dudgeon, who kindly examined the specimens. We may without injustice be very cautious in thinking that the mothborers recorded above are all *Chilo simplex* and till this point is worked out, it will be wisest to leave it in doubt.

REMEDIES.

Many remedies have been proposed for this pest, some suggested by chance observations, some chosen because they were used against similar mothborers elsewhere and it was hoped would apply equally against *Chilo simplex*. It would serve no useful purpose to notice all these ; the principal measures that have been suggested are the following :—

(1) *Selecting and planting only cane free from borer, or steeping the tops containing borer.* It is inadvisable to plant canes containing borer, simply because such a cane is not so vigorous or so full of food for the growing shoot as a sound cane. To what extent it will affect the spread of the pest can only be a matter of conjecture ; a borer in a cane plant would find extreme difficulty in coming to the surface after it had changed to the moth, as cane is planted in irrigated land and the compact wet soil would not allow the borer to emerge. Even if the borer could emerge, the number thus coming out and laying eggs is probably very much smaller than those that come in from elsewhere. Nothing short of direct experiment can show the exact degree of importance of this method. It is advisable to select plant canes free from borer, but this will not, in my opinion, influence the increase of borer in any degree. Steeping canes in some mixture to destroy the borer is the alternative when the canes are so badly attacked that infested canes must be planted. What mixture should be used for this purpose is not specified nor is it stated for how long the canes should be steeped. In Barbadoes I have seen plant canes steeped for 48 hours in lime-water and in this case numbers of dead caterpillars were found in the water. This also takes place in the case of *Chilo simplex.* I have seen no case where I would recommend this to be done. Borer is not so bad in old canes that good cane cannot be got for planting. If it should be so bad, no harm would be done by steeping for 12 to 48 hours in lime-water (one lb. lime to 20 gallons of

water), though the same result would probably follow from steeping in water alone. This does not appear to have any bearing on the question of checking mothborer.

(2) *Burning cane stubble, trash, leaves, &c., after the crop is cut.* As a rule this is a precaution that would in no way affect the insect. It is important in the Southern United States, where the borer hibernates in the cane stubble ; if in India cane was grown for 10 months in the year and during the intervening two months the cane stubble was the only food and habitat for the borer, this precaution would be of immense importance. As it is, the cane when mature is not the habitat of borer ; the insect is in sorghum or maize or in the young cane sown before the other cane is ripe. In Western India at least, and in many other parts of India, the amount of borer in the old canes or cane stubble is practically *nil.* In the Poona District some fields are burnt over after the crop is reaped. This is not connected with the borer but the cultivator does it for other reasons. When this is done, the borer is in the young canes, or in irrigated sorghum.

(3) *Collecting eggs.* This remedy was suggested by Dr. L. Zehntner for the Java mothborers in 1896, and successfully practised in Teneriffe against *Diatræa saccharalis* previous to 1899. (International Sugar Journal, Vol. I., p. 656.) It was recommended in the West Indies by the writer in 1900 (West Indian Bulletin, Vol. I., p. 327) and has there been found a satisfactory remedy. For India it has been suggested in the hope that the eggs, when found, would be the same as those of *Diatræa saccharalis* and would therefore admit of being collected. Unfortunately the eggs are too inconspicuous for collecting except by people trained to the work ; nor are the conditions suitable. In the West Indies, from March to June, all the old canes are cut, all the mothborers come out and lay eggs in the young canes, and therefore all the eggs must be on the young plants. There are no alternative food-plants, no hibernating larvæ, no other course open to the moth than to fly to the young canes and lay eggs. It will be seen that under such conditions it is not hard to be sure of getting *all* the eggs. In India, this is not the case ; the eggs are very inconspicuous ; even to the writer, trained and expert at collecting the eggs of the West Indian mothborer by three years' work there, it has been no easy matter to find the eggs nor is it easy to collect them in any number when they are there. It is extremely easy to pass over the eggs ; they are so inconspicuous, they look so like spots on the leaf, drops of excreta, or a splash of mud. After having collected eggs over many acres of young canes in India, I am convinced that it is not a remedy the cultivator could adopt, even could he be shown what to look for. The conditions are not favourable ; the moths

laying eggs in young canes for at least four months, there is no time when one can be sure that all the moths must be laying eggs in the young canes, which is the secret of the West Indian method.

This season's experience has shown that it is also inadvisable to attempt to collect eggs, for the simple reason that the black eggs are collected, being easily seen, whilst the yellow or white eggs are passed by. Black eggs contain parasites, and these will hatch and destroy other eggs ; they are therefore extremely valuable and the parasites constitute the chief check on the borer. The eggs which should be collected are the white, yellow or orange ones, and these are apt to be passed over. Under the circumstances, the eggs are best left in the plant and not touched ; I have seen no case where I could recommend egg collecting and I do not believe the conditions are generally suitable for this remedy.

(4) *Lights.* It is known that many insects, moths especially, are attracted by lights and by sugar in a liquid state. Both have been used for destroying moths on a large scale and so preventing egg laying. It was natural that this method, used against the West Indian mothborer in former years, should be recommended for the Indian insect, but the Indian mothborer is not attracted to lights. That fact puts this remedy out of consideration at once, and it is useless to attempt to destroy the moths before egg laying by means of lamps. Even when the fields are beaten through to drive the moths or to make them to fly, there is no result ; the moth, unlike some of its allies, shuns light.

(5) *Cutting out diseased shoots of cane* (*dead hearts*). The simplest method of destroying the insect naturally is to catch and kill it. This is possible only at one time, when it attacks young shoots and kills them, the withered shoots showing clearly where the insect is. This method dates back many years ; "In 1879, the Royal Agricultural Society advocated burning the trash, crushing the rotten canes, soaking plant canes in water heated to 125° F., encouraging birds and other enemies of the mothborer, and also cutting out the diseased canes. About the same time Miss Ormerd took up the question of cane pests and recommended that the diseased shoots should be cut out and destroyed." "The practice of cutting out diseased canes is of the greatest value in directly combating the mothborer and is carried out in Barbados at the present time. Writers from different parts of the world have found this a suitable remedy, and so far as can be judged from the available literature, it has been adopted in Queensland, Teneriffe, the West Indies and other localities, with marked success " (West Indian Bulletin, Vol. I., p. 339).

What has been done elsewhere is possible in India with *Chilo simplex*, and we have here the method on which reliance must chiefly be placed. The

method has been suggested by several writers in India; "Later on all diseased canes should be cut out close to the bottom of each near the ground, such canes being destroyed and not allowed to remain on the field. If left when cut, the caterpillars will crawl out and attack a neighbouring growing cane. If the canes are not cut low down, the larvæ may be in the piece of cane remaining uncut and so escape." (L. deNicéville, Indian Museum Notes, Vol. V., p. 173.)

"The pest usually makes its appearance when the cane has fairly germinated and the first indication, in the young shoots, is the withering of the uppermost central leaves. If, when the first sign of withering is seen, the affected cane or shoot is cut down close to the ground and slit up, one or more borers will be found in a tunnel made in the solid cane. Cut close to the ground and burn all affected shoots as soon as withering of the central leaves is noticed. The caterpillars are almost certain to be inside the cane at this time." (J. Mollison, Text-book on Indian Agriculture, Vol. III., p. 121.)

This remedy is discussed more fully in the next section. Of the many remedies in use against other mothborers, this is the one most suitable for the Indian insect.

(6) *Trap Crop.* The remedies in use, or recommended, against *Diatræa saccharalis* up to 1900 are discussed in the West Indian Bulletin. We may extract a paragraph describing another remedy found by observation to be useful both in Barbados and in India. "There is another remedy that is deserving of careful attention. It has been already stated that Indian corn (*Zea mais*) is one of the plants attacked by mothborer. It has been used as a trap crop by cane cultivators in the Canary Islands. I can find but one reference to it, which I will quote: 'Here, (Teneriffe) the borer is also said to prefer maize to cane and when cane was grown by small farmers, they were in the habit of sowing a few grains of maize in spots of cane that were known to be frequented year after year, and when these got full of borer, cutting them out. There is no doubt that it is frequently fond of maize and I have taken as many as 37 in one stalk.' (D.McPhail.) This refers to another borer, probably *Sesamia*, but the same habit is found in *Diatræa saccharalis.* Indian corn is attacked by the mothborer, and from a case that came under my notice I consider it prefers maize to sugarcane. Maize was growing between the young canes, and whilst the canes were free from attack, the maize was eaten up with mothborer, and other caterpillars. Mr. McPhail's suggestion is a sound one, and it would seem to be a simple matter to sow corn between or near the young canes, and destroy the borers, before they are able to complete their life history. It would be necessary to cut out the maize within six

weeks of the first attack, and if the plants were only slightly affected, they might be fed to stock, chaffed up or put in the soil. If they were badly attacked, as would probably be the case, the whole might be burnt with some dry trash, or buried deep in the compost heap." (West Indian Bulletin I., p. 343.)

What is said here by Mr. McPhail with regard to Teneriffe and by the writer with regard to the West Indies applies equally to India. Young sorghum in any stage is attacked in preference to young canes by the Indian mothborer; it is not uncommon to find stray plants of sorghum in irrigated fields of young cane and to find borer eggs on them and not on the canes. It would be of great advantage to localise all the borers in the sorghum or maize plants and then destroy them before they can breed and lay eggs in the young canes.

Out of all the methods suggested, we have two suitable for use in India, adapted both to the habits of the insect and to the conditions under which it lives. Both are direct methods aimed at killing the insect, the one by catching it in the cane, the other by trapping it in corn or sorghum and then killing it. The application of these two methods will vary slightly in different places according to the different crops grown and the alternation of the seasons. In South India the method of applying these remedies may be radically different from that of the plains of Central or Northern India. I here discuss the methods of applying the remedies in South Gujarat, applicable to the Konkan and parts of the Deccan, and probably to all places in Northern or Central India where sorghum is grown with cane or where cane is grown.

South Gujarat. The sequence of crops is as follows :—Cane is planted from December (Bulsar) to April or May (Surat or Baroda) in irrigated fields. Sorghum is grown in the rains, reaped from November (Surat) to January (Jalalpore) and the stubble remains in the fields until May. The harvested stalks are stacked and used as fodder up to the rains. Maize is grown to a varying extent during the rains. The mothborer therefore has three crops in which to live :

Young	cane	from	January to August.
Jointed	do.	from	May to January.
Sorghum		from	August to December.

Sorghum stalks and stubble from December to June.
Maize stalks and stubble from August to November.

The mothborer is actually found in the young canes from January till the sorghum crop is up, in the sorghum crop from August to December, and in the sorghum stubble and stalks from December to June. It is therefore easy to

destroy the mothborer in young canes during the first five months of its growth, at times varying from January to July or August and to trap it in maize or sorghum grown with the canes at the same time. The method therefore comes to :—

(1) Cutting out all young canes attacked.

(2) Sowing maize or sorghum among the young canes so as to have a succession of plants during the first five months.

Looking at the distribution of the mothborers throughout the year, one thing is notable. From December to July, all the mothborers must be in one of the two places, either the young canes, or the sorghum stalks and stubble ; from July to December it is in sorghum, maize or old canes. This is important since we can destroy the insect in the young canes, but cannot touch it in the growing sorghum, maize or jointed cane crops. If it were possible to destroy the sorghum stubble, utilise the sorghum stalks, and so prevent the insect hibernating there, we should destroy all the mothborer except that in the young canes, and these could be destroyed by cutting out the attacked shoots. Under these circumstances there is an additional method, of great importance if it can be carried out, namely, destroying the insects hibernating in the sorghum stubble or stalks. By far the greater number of these are in the stubble ; they hatch from February to July, and infest the young canes. Any measure that will destroy this stubble, will largely check the increase of this pest.

In cutting out dead hearts, there are a few points to be impressed upon cultivators ; from the time the cane comes up, it must be watched and every shoot seen to wither in the centre cut out, very low down. These shoots are either removed at once and burnt with the insect inside, or are split up, the insect killed, and the shoots thrown on a compost heap or otherwise used. Many cultivators know the mothborer caterpillar, but say it comes from the water. They have no idea that by systematically killing it they will prevent it increasing. The whole life-history in young canes occupies from five to six weeks ; so that there may be three or four broods in one crop of young cane, before the cane is commencing to form joints and no more "dead hearts" are found. The killing of every insect early in the season is therefore important, as their increase may be much larger than the number that wander in from neighbouring fields of sorghum stubble. As a matter of observation, quantities of eggs are very often laid in the three-months-old canes which is mainly due to the increase in that field of the first mothborers that come in from the sorghum stubble. No "dead hearts" will be seen after the first five months, as the cane is then forming "joints" and the borer does not eat the growing point but attacks the joints. The

cultivator also thinks that the borer does little harm, as new shoots are formed; this is true to a large extent when the canes are small, but the vigour of the plant is very much tried by forming a succession of shoots which are in turn eaten off. I have seen fields with 95 per cent. of quite young shoots destroyed, and other fields of cane, four months old, with quite 40 per cent. of large vigorous shoots killed; in both of these cases the crop receives a very bad set back, which results in a poor whole crop, or in a very uneven patchy crop with some canes ripening and others half grown. Quite apart from the fact of the later crops, the damage in the young stage to cane is very serious and the cultivator should be made to realise it.

With regard to trap crops, maize or sorghum should be sown in the field when the cane is planted. It comes up quickly and attracts the moth to lay eggs. The first mothborer eggs found in India were found in sorghum growing in a field of young canes. Six weeks after the cane is up, the first sorghum or maize is removed with all the insects and destroyed; this is already a practice in some places, where the cultivator goes over his fields when the canes are a certain height and takes out all such chance plants. There should be a succession of such plants, sown every month, so that when the first is removed, there are others to attract the mothborer; the cultivator is likely to find this out for himself, if he can be induced to sow the first trap crop; the result of the trapping and destroying the first batch of borer in the young canes will be very great, and will not only give the cane a good start but will be a very great check on the increase of borer.

An experiment was made in 1904 on the experimental farm, Manjri, Poona; maize was sown among the canes, at the time they were planted, grew vigorously and was ripening at the time the canes were attacked. This farm is under the control of Mr. J. B. Knight, Special Assistant, Department of Land Records and Agriculture, who had maize sown at various times so as to be at different heights when the cane came up. The experiment failed almost completely; a few borers attacked the ripening corn but the cane still suffered heavily.

During 1905, maize and sorghum was sown with cane in the first week of March on the Pusa Experimental Farm. The maize came on very rapidly and contained borers, none being found in the cane except those of another species (*Scirpophoga auriflua*, Zell.) The sorghumg rew more slowly and after the removal of the maize was found to be infested with borers. This was removed with the insects in. In this case the mothborer evidently preferred the maize and sorghum and the results obtained are at variance with those obtained at Manjri in the previous season. The experiment will be

continued and the remedy must be regarded as an experimental one until further trials are made in different localities.

With regard to the destruction of sorghum stubble, it is not easy to make any definite recommendations. This is the home of the hibernating larvæ which hatch at any time from February to June and infect the crops. If that stubble could be destroyed as soon as the crop is reaped, enormous numbers of mothborer would be destroyed. The sorghum stalks are less important as fewer larvæ are in them; but they are also a source of infection. The practice of stacking these with a covering of earth is useful, as it prevents the moths emerging at any time to lay eggs. The destruction of sorghum stubble is so large a matter that probably nothing can be done but teach the cultivator and try to persuade him to do it of his own accord. Should the mothborer ever prove a very serious pest to sorghum as it was in 1903 in Sind, it may be necessary to take action to compel the destruction or removal of this stubble. It is a matter of the greatest importance, which is best left for the present in a tentative condition.

Other Districts.—I have discussed the methods of application in South Gujarat as this affords an example of the course applicable probably in most parts of the plains, with variations to suit local practices. At Poona, irrigated sorghum is grown as well as irrigated cane, and as the mothborer cannot be attacked in sorghum without destroying each attacked plant, the methods above described will not be so useful as they would be elsewhere. Still they are the only methods and should be adopted. In Bassein (Bombay), the borer lives in the canes all the year, and its destruction in the young canes is therefore of the greatest importance, whilst the question of destroying sorghum stubble does not arise. For other places special circumstances must be taken into account and the remedies will be successful in proportion as they fit in with the distribution of the insect in different crops throughout the year.

This and other cane borers will be discussed in a later number of the journal, with special reference to the conditions obtaining in Behar.

EXPLANATION OF PLATES X & XI.

PLATE X.—Fig. 1. Egg cluster on cane leaf, natural size.
Fig. 2. Part of egg cluster magnified twelve times.
Figs. 3 & 4. Caterpillar, normal dark spotted form × 3.
Figs. 5 & 6. Caterpillar, hibernating form × 3.

PLATE XI.—Fig. 1. Pupa × 3.
Fig. 2. Moth, wings in repose × 3.
Fig. 3. Head of moth from side × 3.
Fig. 4. Female moth × 3.
Fig. 5. *Cotesia flavipes*, Cam., a parasite of the caterpillar, much magnified.
Fig. 6. Male moth × 3.

EDUCATION IN INDIAN RURAL SCHOOLS.

A PLEA FOR NATURE STUDY.

By F. G. SLY, I.C.S.,

Offg. Inspector-General of Agriculture in India.

I REGRET that I have no knowledge of the science of education, which is now a specialized subject, but the great interest that I have taken for years past in Indian rural schools must be my excuse for writing this article. In discussing the principles of education in rural schools, I do not wish to go beyond the statement made in paragraph 21 of the famous Education Resolution of the 11th March 1904, where the Government of India lay down that 'the aim of the rural schools should be not to impart definite agricultural teaching, but to give to the children a preliminary training which will make them intelligent cultivators, will train them to be observers, thinkers and experimenters in however humble a manner, and will protect them in their business relations with the landlords to whom they pay rent and the grain dealers to whom they dispose of their produce.' This policy received the full support of the Board of Agriculture, who considered that the future of Indian agriculture is bound up in it. I have nothing to propose that goes beyond that policy, but wish to offer a few suggestions upon the best means of giving effect to it. This policy is based upon what are now almost universally accepted as the proper principles of education, which no longer aims at the acquisition of facts, but the development of the intelligence, by training the child's power of intelligent observation of his familiar surroundings. The child is taught to *know*, by training him to *observe*, to *think* and to *do*. The central aim of village rural education should be a preparation for complete living in the village. Whilst we may not go to the length of accepting the extreme maxim of Rousseau 'Let the teacher tell the child nothing, but lead the child to discover everything,' we may fully accept Herbert Spencer's saying 'Children should be *told* as little as possible and induced to *discover* as much as possible.' The principles of this policy thus demand that we should substitute experiment and observation for rote work, deal with

concrete objects before abstract, proceed from the known to the unknown, and above everything base instruction upon the familiar surroundings of the child. The familiar surroundings of the rural schoolboy are essentially agricultural, so that his education should very largely be based upon agriculture.

Now I have no vain aspiration that the rural school should aim at producing expert agriculturists versed in the agricultural sciences; its object should be to produce cultivators with their intelligence better trained than that of their forefathers, whose great hereditary knowledge of agriculture is based upon centuries of experience rather than upon intelligent reasons. Any attempt to teach scientific agriculture, or indeed to teach agriculture at all as a separate subject, is bound to end in failure. The scheme put forward for Bengal in that Government's Resolution of the 7th February 1905, excellent in many respects, seems to me to err in making agriculture a separate subject of study in classes II and III. It cannot be too often insisted that this system of education in its relation to rural schools is a *method* of study and not a *subject* of study. 'It is a means of developing mental power in the pupil under the careful guidance of the teacher, by encouraging close observation of the things of nature which lie about him, and by begetting an attitude of enquiry into their meaning so that the truth is discovered through the exercise of the pupil's own activities.' This principle should be adopted in the teaching of *all* subjects in rural schools. My experience is that in India it has generally been confined to the Reading Lessons instead of being extended to all the subjects taught. The correlation of the principle to the three R's, the subjects of primary importance in rural schools, must be carefully secured. Reading should be taught from lessons in the readers dealing with the child's surroundings *from the child's standpoint* ; writing and composition should be taught on the same system ; and all arithmetic sums should be drawn from the same source. Its supreme suitability to the inculcation of moral principles is obvious.

Whilst fully accepting for India this principle of education, common to the whole world, it is essential that the system based upon it should be thoroughly Indian and suited to the local conditions. I may be permitted to remark that, in my opinion, some of the past failure of the Indian Educational Department has been due to a neglect of this truth. In importing western principles of education, we have sometimes also imported western systems, which are wholly unsuited to Indian conditions. A prominent instance that occurs to me is the introduction of Kindergarten teaching into the Central Provinces Schools. Instead of taking the principles of Froebel and Herbart and working out an indigenous system on these principles, the English system with the same 'gifts' based upon the familiar surroundings

of English children was introduced without any change to the Indian child with the result that the principle itself was thus set at defiance, the outcome being a complete failure. The most striking example of success in the opposite direction that has been brought to my notice is the system followed in the low caste Panchama Free Schools of Madras by Mrs. Courtright, who has evolved a thoroughly Indian system out of correct general principles, which is described by her in a pamphlet entitled 'How we teach the Pariah.' The system of education followed by her is based wholly upon object lessons—not illustrations—the commonest objects seen and used by the child in his everyday life.

In order to introduce these right principles of education into rural schools, the first requirement is proper lesson books, not only for reading but for all subjects in which lesson books are used. It is universally recognized that the preparation of elementary lesson books is one of the most difficult of tasks, which can only be successfully accomplished by a real master of his subject, who has also had considerable experience of teaching. Several provinces have already revised, or are in process of revising, the Reading Books. I have been privileged to see some of the revisions, and considering the difficulty of the task, I may without undue criticism describe some of them as defective. The main defect is, in my opinion, that the authors' have produced primers of elementary science instead of lessons on Nature Study. In short, they have treated it as a *subject* of study instead of a *method*. They have endeavoured to impart the elements of agricultural or other science by a systematic and logical lesson on the subject instead of using the natural objects and adapting them to the questioning experiences of the young child. The difference of attitude has been well expressed by Professor Bailey :—'When the teacher thinks chiefly of his subject, he teaches a science ; when he thinks chiefly of his pupil, he is teaching Nature Study.' The lesson book with which I am best acquainted, Fuller's Primer of Agriculture, fails in this respect.

Another common defect is that the lessons are not written *from the child's standpoint*, but with the intention of imparting abstract knowledge. Some of the lessons also clearly fail through an insufficient knowledge of the agricultural surroundings of the child. I have seen recommendations for the introduction of western methods of agriculture, which are positively harmful. The educationist in India is fully occupied with inspections and other departmental work, so that he cannot be expected to have a minute acquaintance with Indian systems of agriculture. The officers who should know most about the latter subject are the Director of Agriculture and his staff. For this reason, I plead for closer co-operation between the Educational and Agricultural Departments. In most

cases it is impossible to secure a single officer who has thorough experience of child education and of Indian agriculture. The best arrangement would, therefore, seem to be that officers of both departments should collaborate in the production of suitable lesson books. At any rate, I suggest that a revised lesson book should in no case be introduced until the provincial Director of Agriculture has been consulted upon it. If the Director is not able to help with advice as to the method on which the lessons are prepared, he can at least secure that the agricultural facts are correctly stated in them. If any of the lessons deal with subjects (*e.g.*, insect life) upon which he is not competent to advise, he can refer the matter to the Imperial Department of Agriculture with its larger staff of specialists. The final decision must of course rest with the Education Department.

A further important mistake which has sometimes been committed is the introduction of one lesson book throughout a province, in disregard of the fact that the surroundings of the child in one tract are very different from those in another tract. I have seen a lesson based on a cotton flower taught in a district where cotton is unknown; I have seen a lesson on the dog dealing almost wholly with important English breeds which the child could not possibly materialize. The enormous differences in the methods of agriculture followed in separate tracts must be recognized and separate lesson books prepared for each tract.

I need not, perhaps, refer to the very important point that the lesson books must be in the vernacular language 'understanded by the people,' employing only common simple words which the child can appreciate without effort. I believe that this is now universally accepted by every Education officer.

In addition to the lesson books, the illustrations must be all drawn from familiar objects, and above all the master must use as lessons the objects themselves. Lesson sheets hung on the walls of rural schools often deal with objects with which the child is wholly unfamiliar. A good set of lesson sheets for each tract would be a considerable help to a proper system of education. But of much greater importance, the master must use real objects in order to cultivate in the child the habits of observing and thinking. In this matter school gardens are of primary importance. I recognize the difficulties that in some parts stand in the way of providing each rural school with a garden, but these might be overcome more often than they are. Where this is impossible, a very great deal can be accomplished by growing plants in boxes and pots. The right use of a school garden or school pots is not always enforced. I have seen school gardens in which the whole of the work was done by the school watchman and which served the sole purpose of growing

a few English vegetables for presentation to an inspecting officer. The best school gardens visited by me serve the useful purposes of beautifying the school surroundings and of giving some manual training to the children, but even these objects are of secondary importance. The real purpose of a school garden should be to supply materials for object lessons, in which the pupils can study the growth of plants. It should be a garden where 'nature is studied in its relations to the child, from the child's standpoint, by the teacher with the children.' If there is not room for each child to grow his own patch, each class should jointly cultivate its own plot, not in order to produce the best results but to observe and study plant growth. Under the guidance of the teacher, the child should observe the parts of a seed, the plant food in it, the process of germination and the conditions necessary for it. In each stage of the growth of the plant, he should pull up a specimen and observe the roots, their uses and their growth ; the stems, their uses and structure ; the leaves, their uses and structure ; the flowers, their parts and uses, and methods of fertilization ; the fruits and seeds, their formation and uses, methods of dispersal and the like. He should observe the soil and its composition, the effect of plant food and manures. The garden should be deliberately used to give object-lessons in failures as well as in successes in connection with soils, drainage, manures, weeds and the like. The child's plot should be used like a slate to put things on and to rub them off for educational purposes. It will teach him habits of close observation, of thoughtfulness and of carefulness ; he will learn by *doing*. The most informing book on the uses of a school garden that I have seen is 'Nature Teaching' by Dr. F. Watts of the Imperial Department of Agriculture for the West Indies. School gardens need by no means be expensive ; a portion of the school compound can often be utilized, and the commonest seeds obtained free in the village are as useful as those purchased from a merchant. In any case, the cost of growing some plants in pots and boxes is infinitesimal. Plants collected from the road-side and cultivator's field can never take the place of the school garden. The child must *do* the things himself ; he must sow his own seed and observe the growth of his own plants.

Above everything success depends upon the teacher and his training. Whilst the school children are the sons of cultivators, the masters are often drawn from the 'literary' castes, who may know something about books but little of Nature. Their heredity and training are wholly towards *rote* systems of education, and there is a great mass of prejudice to overcome before they can be turned into enthusiastic teachers of the modern system. I suggest that more efforts should be made to recruit schoolmasters from

the same class as the boys. By selecting the best of the cultivators' sons for training as masters, I am inclined to believe that much more rapid progress will result.

In considering the difficult question of the training of rural schoolmasters, again I do not wish to go beyond the principles laid down in the Resolution of the 11th March, 1904, which says :—'Steps are being taken to supply courses of training specially suited for teachers of rural schools. These do not attempt the impossible task of reforming the agricultural practice of the peasantry by the agency of village schoolmasters imbued with a smattering of scientific theory. They serve the more limited and practical purpose of supplying the village school with teachers whose stock-in-trade is not mere book learning, and whose interests have been aroused in the study of rural things so that they may be able to connect their teaching with the objects which are familiar to the children in the country schools.' Two systems of training are under trial in India. The first consists of a short course lasting about six months in a special class attached to an agricultural school or college. I have had considerable experience of this system at Nagpur. There the Education Department has avowedly aimed at a dual object ; they have endeavoured not only to give a training in Nature Study, but also to teach the students some elementary knowledge of improved methods of agriculture in the hope that they would become not only good schoolmasters but also useful members of the village community in introducing new ideas about agriculture to the children's parents. I can confidently say that in nearly all cases the second object has not been realized, more harm than good resulting from attempts at agricultural improvement by such an agency, whilst the training of the student as a schoolmaster has much suffered. The instructors have imparted to their students a smattering of the agricultural sciences, which is quite insufficient to produce any real result, and have neglected their primary duty of imparting instruction in methods of Nature Study. The chimera of attempting to introduce improved agricultural methods by the agency of schoolmasters should be wholly abandoned and the training confined to the single purpose of producing schoolmasters equipped with a full knowledge of the methods of Nature Study. Even with this change, there remains the strong objection that a course at an Agricultural College is divorced from all other training in pedagogy. The shortness and concentration of the course enable a large number of masters to be trained in a short time, but the tendency towards cramming is thus encouraged. The principles should permeate the whole course of training and not be confined to a short separate course. For these reasons, I am personally of opinion that better results will be secured from

instruction in a Training College where the method is systematically taught throughout the whole course, provided that proper arrangements for teaching are made at the college. The success of the institution will largely depend upon the instructor, who must possess two qualifications, a knowledge of agriculture and a knowledge of methods of teaching. In addition to a knowledge of plants, animals and other natural objects, he must possess 'an intimate knowledge of the laws of development of the child, how the mind operates, the needs and interests of the child, its activities and its sympathies. These qualifications can only be secured by selecting a candidate who is a graduate of an agricultural college and who has also passed through a course of instruction in methods of teaching at a Training College. It will thus be necessary either to select an agricultural graduate and put him through a course at a Training College or to select a good student from a Training College and send him to an Agricultural College. In the selection of such a candidate, the personal element is all important, for the instructor must be an enthusiastic believer in the principles that he is to teach.

The equipment of the Training College must also be suitable, including provision for indoor study and outdoor practice. There should be a reading room and library equipped with the most useful books on pedagogy and nature study ; a class room completely fitted with material for indoor experiments ; a practice room where the student can try his prentice hand ; and above all a plot of land for outdoor work. The plot of land need not be large but it is very important that it should be managed on correct principles. At one Training Institution, I found that the school farm was worked like an agricultural experiment station, comparative tests being made on fairly large plots of different kinds of manures. This seems to be a radical misconception of the province of a school farm. It is all right to plan an object-lesson on the utility of manure, but this is very different from attempting to solve an agricultural problem of the comparative value of several kinds of manure. The main object of the school farm should be to train the masters in the method of managing a school garden and of growing and utilizing its object-lessons. There should be a model school garden, and, in addition, each student (or group of students) should have a separate plot to work as a school garden. There may also be other plots to show object-lessons on a larger scale. Again I would recommend close co-operation between the Education and Agricultural Departments in the management of Training Colleges for rural schoolmasters. The Agricultural Department should help in securing a really efficient instructor, should advise as to the curriculum, should inspect the school farm, and should assist in the examinations.

Such are the principal recommendations that I wish to make in regard to education in rural schools. If the correct principles of education are followed, the results must be good. The Education Department will thus draw closer the connection between the teaching and the calling of the pupil. And a most important indirect benefit is that the active interest of the parents will be enlisted in favour of the school, for the cultivator will be able to understand and appreciate the training received by his son. There is nothing novel in my statement of the general principles. Indeed the wording has been taken almost without change from other publications, more particularly the 'Annual Report of the Ontario College of Agriculture, 1904,' and 'Some principles of teaching as applied to lessons in Agriculture', by Colonel Hicks, Senior Inspector of Schools, Jamaica. If I have succeeded in showing how some of these principles may be adapted to Indian conditions, my object will be attained. A very great advance has been made of recent years in Indian educational methods, and my belief in the vital importance of education to the Indian cultivator must be my excuse for making a small effort to aid in that advance.

COMMERCIAL FERTILIZERS.

By Dr. ADOLF LEHMANN, M.A., B.S.A., PH.D.,

Agricultural Chemist to the Government of Mysore State.

In India the persons most deeply interested in commercial fertilizers from a consumer's standpoint are undoubtedly the planters. Nevertheless other agriculturists are beginning to use them and with the present developments in agricultural investigations in India a much greater demand and more general use of commercial fertilizers will undoubtedly take place, for, judging by those soil analyses (other than from coffee and tea estates) available, as well as from the appearance of the crops, fertilizers are needed in India even more than in those countries in which they are most extensively used at present.

The principal commercial fertilizers produced in India are the various oil cakes, bone meal, dried fish, saltpetre and mineral phosphates, and to a limited extent dried blood. Of these the various oil cakes, dried fish and saltpetre are subject to very great differences in composition. Not only do the various kinds of oil cakes vary much in composition from each other; but the different samples of the same kind of oil cake vary almost as much. This has not been sufficiently recognised up to the present. One sample of white castor poonac is, for example, considered to be practically of the same value as any other. Dr. Leather has, years ago, pointed out the great differences which exist in the nitrogen content between the castor cake of Bengal and that from the Bombay Presidency, and below are given some of the analytical results obtained for white castor cake in Mysore State.

White Castor Cake.

No. of sample	14b.	3	52	42	51	50
Per cent. of Nitrogen... ...	8·69	7·38	7·01	6·47	6·40	4·53

In Collin's Agricultural Chemistry, page 60, the limits given for Indian Castor cake are 3·75 per cent. of nitrogen (the lowest of the Bombay castor

cakes) and 8·00 per cent. (the highest for Bengal castor cake). It is not stated, however, if in this table any distinction has been made between *white* castor and *black* castor cake. The difference between these is claimed by some dealers to be that the former is decorticated before milling while the latter is not. This may be the case, but samples of white castor and black castor of practically the same nitrogen content differ considerably in appearance and some other respects.

In oil cakes sold locally in Mysore under the name of *ippe* (probably *Bassia latifolia*) the difference is also very considerable. Below are given the results of analyses of some samples.

Ippe Poonac.

No. of sample	46	49	50	51
Per cent. of Nitrogen ...	4·14	4·01	1·92	1·80

This striking difference may however be due to a difference in variety. No. 46 and No. 49 were decidedly lighter in colour than the other two.

Quite as marked a difference as this is, however, found in the composition of the different samples of safflower cake (*Carthamus tinctorius*) grown in the neighbourhood of Hubli where it is known as *Kardi*.

Safflower Cake.

No. of sample	206	32	207	40
Per cent. of Nitrogen ...	8·03	6·43	4·86	3·22

And in a sample of safflower cake of unknown origin the nitrogen content was only a little over 2 per cent.

The composition of *Neem* cake (*Melia Azadirachta*) is much more uniform, varying in the samples analysed here from 5·99 % of nitrogen to 4·43 %. In the case of *Ippe* and *White castor* the poorer samples contain only about half the amount of nitrogen found in the best samples. It is quite possible, therefore, to find two samples of the same kind of oil cake, one of which is worth twice as much as the other; and it requires no further demonstration to prove the fallacy of buying oil cakes without knowing more about them than simply their name, if we can get more exact information regarding their quality: for no one is prepared to pay twice as much as he needs to do for any article, not even a commercial fertilizer, and as long as one sample of

white castor or *ippe* or *kardi* is considered as good as any other sample having the same name and sold for the same price, the person who gets the poorest kind of sample must pay twice as much for the plant food he gets as some one else who happens to get the best sample.

In countries in which commercial fertilizers are used to a large extent, regular fertilizer laws exist and are enforced by the state. These vary in different countries, but their object in all countries is to give the consumer a chance to know what he is buying. In India the demand for commercial fertilizers may not yet be sufficiently great to justify the passing of laws on this point, and even if they were passed now, there is no way of enforcing them. It is highly desirable, however, that dealers should voluntarily guarantee the quality of their fertilizers. And as soon as dealers recognise that consumers value such a guarantee sufficiently to justify the expense of repeated analyses, they will be ready to give the guarantee asked for. The United Planters' Association of Southern India is trying to induce all its members to buy, as far as possible, all their fertilizers from firms giving them a guaranteed analysis of the fertilizers offered for sale. As an indication that dealers in commercial fertilizers are prepared to do what they can in this matter, it may be stated that three firms have built little laboratories solely for the purpose of enabling them to guarantee the fertilizers they sell. But in order to induce those who already guarantee their fertilizers to continue doing so in future, and to induce others to do the same, it is necessary for the consumer to realize fully the advantage a guarantee gives him, and to make use of those advantages.

To see at a glance which is the cheapest, considering quality, of a number of fertilizers offered for sale, it is necessary to reduce them all to the same standard. The standard generally adopted is the price of 22·4lbs. of the fertilizing ingredient, or one per cent. of a ton. This is called a "unit." If, for an example, an oil cake contained $6\frac{1}{2}$ per cent. of nitrogen, a ton would contain $6\frac{1}{2} \times 22{\cdot}4$lbs. of nitrogen or $6\frac{1}{2}$ units of nitrogen. Therefore, if we divide the price of the fertilizer per ton by the figure representing the percentage composition of any *one* food ingredient, we obtain the price per unit. This can of course only be done with fertilizers which contain almost exclusively one constituent of plant food, as for example, the oil cakes in which the percentage of phosphoric acid is generally disregarded. If a fertilizer contains more than one constituent of plant food in quantities sufficient to require their consideration, it is necessary to fix an arbitrary relation between the value of the chief constituents of plant food. This is generally done by taking the average retail market price of these constituents for the past few months. For India these would be very difficult

to obtain. In one of the latest bulletins received from America, Bulletin No. 115 of South Carolina, they are given as follows :—

		Cents.		As. p.		Rs. as.	
Nitrogen in oil cakes ...	... per lb.	14	=	7 0	or	9 13	per unit.
" dried blood ...	... " "	$16\frac{3}{4}$	=	8 $4\frac{1}{2}$	"	11 11	"
" in Nitrates ...	... " "	$15\frac{3}{4}$	=	7 10	"	11 0	"
Potash in Sulphates	... " "	$5\frac{1}{2}$	=	2 8	"	3 12	"
Phosphoric acid (available)	... " "	$4\frac{1}{2}$	=	2 $1\frac{1}{2}$	"	3 0	"

A table like this is of course subject to constant changes, but it gives an idea of the relative commercial value of the fertilizing ingredients. Most commercial fertilizers contain chiefly one fertilizing ingredient. To find the value of this, if other ingredients are present as well, the value of the latter must be deducted (according to some fixed standard as above) from the price and the remainder divided by the figure representing the percentage of the main constituents.

What has been said of the various oil cakes in regard to difference in quality, applies equally to dried fish and saltpetre. To illustrate this some analytical results obtained with samples of dried fish are given below. These were all sent from the West Coast of India :—

Dried fish.

No. of sample	2	29	47	6	5	7	8
Nitrogen	3·96	4·24	6·17	6·98	7·61	8·72	12·00
Phosphoric acid	1·73	4·65	7·51	4·75	5·42	6·12	3·37
Insoluble residue	2·71	38·47	27·38	7·40	3·48	9·73	......

Sample No. 8 contained simply skins taken out from a part of sample No. 7 and is, therefore, not strictly a sample of dried fish. Attention is drawn to the large percentage of sand (insoluble residue) in samples Nos. 29 and 47. These indicate either carelessness in drying or actual adulteration.

As the demand for commercial fertilizers increases, the temptation to adulterate will also be greater, and unless something is done to stop this, it will soon be difficult to get pure fertilizers. Such adulteration would of course have the tendency to widen the differences which already exist in the quality of individual samples of fertilizers, and further increase the lottery connected with their purchase. The only way to avoid this is to demand a guarantee as to their composition, before buying fertilizers, or to buy them on the unit system. No doubt there are difficulties in the way of this, but they are not insurmountable.

PLATE XII.

On the left, a branch of an orange tree with the parasite in full seed; on the right, a branch free of parasite.

A J I

ORANGE CULTIVATION IN COORG.

By GASTAV HALLER,

Assistant Director, Land Records and Agriculture, Coorg.

Of the fruit trees in Coorg, oranges are by far the most valued. There are several varieties, of which the "Loose Jacket" ranks foremost. It is so named, because the skin covers very loosely the eatable fruit. Since the deterioration of coffee cultivation, more attention is being paid to orange cultivation. The demand far exceeds the produce and for years to come there can be no fear of over-production. In Coorg, oranges thrive best where the monsoon rainfall is not high, where heavy mist and fog are exceptional, and where high winds do not prevail. A fairly good soil is also necessary.

The method of cultivation is very simple. Seeds are sown in nurseries, where the young plants remain until they are about one or two feet high, and then they are transplanted 18 to 20 feet apart, *i.e.*, 109 to 133 trees to the acre. The only attention subsequently necessary is to protect the plants from damage by cattle, and to keep the field clean from weeds or shrubs.

After six to seven years the first crop is picked, and if a garden is to be a success the trees should be manured yearly with either cattle manure or leaf mould. But very little is done in this respect, and the orchards are generally left to take care of themselves. The time of flowering is October to December or April to June. The fruits from the October blossom are of very little use, as they do not ripen properly, forming the so-called monsoon crop for which there is no demand in the market. The crop from the April blossom, which is of great value, is harvested from January to March and is known as the hot season crop. One dozen oranges of the latter sell at from four to eight annas. Very little care or attention is devoted to regulating the flowering of the respective crops. Some cultivators beat down the flowers with a long bamboo. This is successful, if carefully done, and produces the result that the trees are in flower again in April, thus yielding the crop in January. It would perhaps be more effective if the twigs bearing flowers were cut off; but such pruning would be very troublesome.

Experience has shown that after thirty years the orange tree ordinarily begins to decay. But this is to a great extent due to neglect of the trees. The existence of trees older than thirty years in full vigour, and yielding good fruit, is evidence that if care be bestowed the vital powers of orange trees are not necessarily limited to thirty years. But many orange trees get destroyed within a much shorter period if attacked (a) by a parasitical creeper belonging to the Loranthus family, or (b) by two kinds of worms which bore through the stems.

As regards the *Loranthus creeper* it is commonly known in Coorg by the natives as "Bandalike" which is interpreted in the dictionary of the Rev. Dr. Kittel as follows:—"A parasitical plant; the parasitical plant *Epidendrum tesselatum*." This parasite is well known to almost every ryot in Coorg. It attacks almost every species of tree and kills the largest forest trees. The leaves and colour resemble very closely those of the trees on which they feed. The flowers have a dark red colour and each plant distributes millions of seed. Each fruit contains one seed, which is enveloped in a very strong mucilaginous pulp; the seed is carried to another tree by birds, to which it adheres. The propagation is therefore by seed, and not by roots. If the plant is not disturbed, it assumes great dimensions, spreading roots over the trees on which it grows and destroying them in a few years. The means of checking this parasite are very simple; the branches affected must be cut off together with the parasite, as otherwise, it feeds on the dying branches and still succeeds in ripening its seed. Simple as the method of destroying this kind of evil is, yet but rarely is any attention paid to it. Of the annexed photographs, Plate XII shows two branches of an orange tree. One is attacked by the Loranthus creeper which is in full seed, and the other is without the creeper. Plate XIII gives a general idea how this parasitical plant attacks the orange tree.

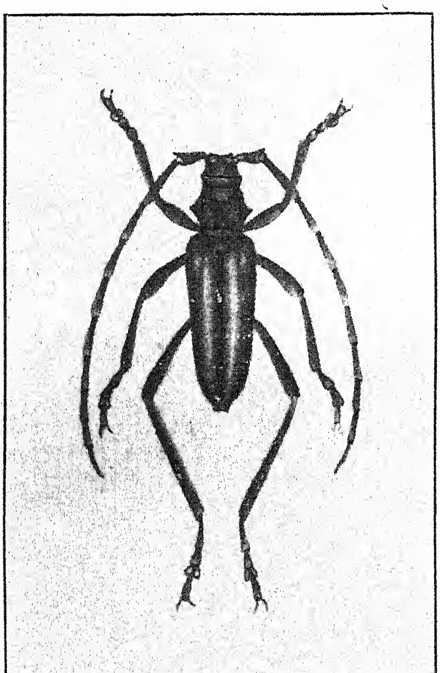
As regards the borer, the problem is more difficult. The boring worm becomes a beautiful green beetle, *Callichroma* sp. In the bores is also found an insect (a Locustid) which is apparently predaceous upon the borer. This insect is the enemy of the beetle and when placed near it sometimes attacks it furiously and kills it. The former is very powerful and if carelessly held can bite so that the blood flows. Mr. H. M. Lefroy, Entomologist to the Government of India, on consultation kindly furnished me with the following information:—"The *Locustidæ* are often predaceous and your case is a very interesting one that should be on record. * * * Tree borers are usually not easy to deal with. We found the bent wire for extracting the grubs, kerosine injected into the bores, and catching the beetles by hand in the early morning, the best remedy for tree borers of this kind in the West

PLATE XIII.

Infested Orange branch.

A J I

Indies. It all depends upon the time of emergence of the beetles." Careful enquiries go to show that these beetles and locustids emerge from May to September, *i. e.*, about the same time as the coffee borer. The worm bores in intricate passages through the trees, and leaves behind it a very hard mass of pulp so that the insertion of wires or injection of kerosine into the bore holes is impossible. These insects prefer trees which are not sappy and fortunately it takes a good many borers to kill an orange tree. The best remedy would thus appear to be to manure the gardens heavily so as to keep the trees in good condition. Old trees, which are beyond recall, should be cut down and burnt in order to destroy all eggs, worms or beetles which they may contain.



ORANGE BORER BEETLE. NATURAL SIZE.

Holders of orange gardens need one word of caution in the selection of seed. Instead of procuring the very best oranges for seed and selecting from such the best seed, there is as a rule no care devoted to this important subject. Imperfectly developed seed cannot produce healthy plants, and although subsequent care with regard to manuring may improve the tree, yet with a little attention at the outset much disappointment may be saved.

CO-OPERATIVE CREDIT IN THE UNITED PROVINCES.

By J. HOPE SIMPSON, I.C.S.,

Registrar of Co-operative Credit Societies, United Provinces.

In the accumulation of practical experience of co-operative village banking, the United Provinces have been peculiarly fortunate. Numerous co-operative banks of this type were founded in 1901, as an immediate result of Mr. Dupernex's labours, and the record of their success or failure has proved of the greatest advantage at the present time, when work has been commenced on broader and more methodical lines.

The village banks were constituted on the Raiffeisen model slightly modified, and were governed by a committee (*Panchayat*), which was assisted in the duty of supervision by Supervisors (*Girdawars*), and with powers strictly limited by rule. The rules provided for the details of working and prescribed (*inter alia*) the terms for and on which loans might be granted, the purposes for which they might be taken, the rate of interest which they should carry, and the rate which the bank should pay on the money borrowed by it.

Of the banks then constituted, about one-third have survived as working bodies, the remainder being either moribund or dead. It is the purpose of this article to examine the causes which have led to the failure of so many of the institutions, and to describe the steps which have been taken to avoid these causes in the societies which have been reconstituted, and in those new ones which have sprung up during the course of the last twelve months.

The majority of the societies had no chance of success from the outset, and it is a testimony to the soundness of co-operative principles that so many successful societies are now at work. The inception of the co-operative movement in these Provinces lay not with the people but with the Government, and the formation of village banks was a direct consequence of Government orders. Neither the officials nor the landlords by whose action the banks were opened, nor the members of whom they were composed, had any

intimate knowledge or any practical experience of the principles of co-operative effort. It is a first essential to the success of co-operation that the members of a society should act voluntarily, and that each member should have confidence in the rectitude and honesty of those with whom he associates and for whose debts he takes upon himself the responsibility. At the outset of the movement there was in most cases no question of voluntary membership. Cultivators became members, not with any intention of contributing to a joint fund and enjoying the benefits which such a fund would confer,—not with any idea of combination in order to obtain credit at more favourable rates than are usually granted to the individual cultivator,—but partly on account of pressure brought to bear by the official or the landlord, and partly in the hope that, in virtue of the payment of a four-anna entrance fee, each member would be entitled to unlimited credit at a favourable rate of interest. The capital provided was not sufficient for the needs of all the members, and the majority of the societies contained a number of high-caste cultivators who obtained favourable consideration at the hands of the Panchayat, and being held more reliable than their low-caste fellow-members, were granted loans out of proportion to their number. These loans there was every temptation not to repay, as common justice demanded that on repayment the money should be lent to some other member, who had not in the first instance received any benefit. The Panchayat, consisting of members of various castes, and the members themselves, in many cases recruited from almost every caste in the village to which the operations of the society extended, were unable to bring effective pressure to bear, loans were not recovered, interest was allowed to run on, and finally the bank died a not unnatural death. Such is the life history of many of the societies which were founded in 1901.

A further cause of failure has lain in the rules and accounts, which were framed for the assistance and guidance of the banks. It has to be borne in mind that in the majority of cases the banks were founded in villages where no professional assistance in account-keeping could be obtained. The person, to whom this duty was confided, was as a rule the sub-agent of a zamindar, or the clerk of a Court of Wards' Estate. They did not understand the method laid down for account-keeping, and in many cases were most unwilling servants of the Society. Their labours were gratuitous, and from the existence of the Society they personally could draw no profit. It was consequently to their advantage that the Society should cease its operations. Where semi-professional assistance of this description was not available, and a literate cultivator was appointed to keep the accounts, the result has usually been confusion. With the best of good will, the accountant-agriculturist has not been a success.

In the rules, again, the village societies have found a stumbling-block. The ordinary village member looks upon them in much the same light as the Penal Code, and lives in constant dread of trouble in case of breach of their conditions. The experience gained goes to show that rules should be reduced to the minimum consistent with statutory requirements, and that much which was originally provided for by rule, should be left either to the bye-laws or to the discretion of the Panchayat. This view has been accepted by the Government of India.

Besides the difficulties mentioned in connection with the recruitment of members, and the rules and forms of account, there has been in the raising of capital a further serious impediment to success of the banks. The working capital of the societies was raised in three ways. Commonly it was collected by subscription at rates of interest very much below the market rate, from interested landholders and other native gentlemen. It was in certain instances advanced by Government, also at low rates of interest. In some cases a portion was raised from deposits by the members of the society. In almost all cases the amount of capital supplied was insufficient for the requirements of the members. It has also been inelastic. There was no method in vogue whereby the capital of a village society could be readily expanded or contracted in accordance with the fluctuating requirements of the members. If more capital than that at present in the hands of a village society is necessary, it can only be obtained at the same rate of interest as that paid on the initial capital by the exercise of official pressure, express or implied, and this, as may be readily understood, forms a serious obstacle to expansion. At the same time the local societies, having enjoyed the advantage of capital at a very low rate, are not willing to pay the increased rate necessary to attract the money of the ordinary investor. It would entail payment by the members of a higher rate of interest than that which they now pay on loans from the Society, and they feel, unreasonably, no doubt, but still naturally, that it is a breach of faith on the part of the Panchayat to charge them two pies in the rupee for accommodation which has hitherto been provided at one pie and a half.

It is of course highly desirable that, as far as possible, the village societies should work on capital provided in the village from the members' hoards. That this will in time be the main source of capital cannot be doubted. Experience in certain districts leads to this inevitable conclusion. In most districts, however, there is a distinct aversion to making deposits. The societies are looked upon as a freak of Government, and are not generally regarded as in any sense permanent, or as suitable places in which to deposit money.

The investor of the towns has not been attracted. It is not possible that under present conditions he should be. The security of the village societies is not known to him ; of their very existence he is probably in ignorance. It is, however, eminently necessary that the village societies should be brought into touch with the world of finance, if they are to be of general utility. Whatever scheme is adopted must contain, as essential features, the existence of a head-quarters' organization which is in a position to deal with the larger capitalists and the joint-stock banks upon a business-like method, in which it is realized that eleemosynary contributions at low rates of interest must in the nature of the case be strictly limited in amount, and that practically unlimited capital can be obtained if the business of the societies is sound and they are willing to pay a fair rate of interest for the capital required. The existing organization societies do not meet the needs of the case. They consist of landlords and others, who have subscribed certain amounts in order to finance the existing societies. They look upon these subscriptions as of a semi-charitable nature, and in many cases consider that their duty in connection with co-operative societies has ceased, when they have paid the amount expected of them. They are as a rule not men of business, and their interest in the societies is purely ephemeral and dependent on the interest taken in those institutions by the District Officer.

Such is a brief account of the initial difficulties under which the village banks in the United Provinces have laboured, and under which they probably labour elsewhere. They are of three descriptions, inasmuch as they relate to the *personnel* of the society, its rules and accounts, and the raising of its capital. It remains to describe the steps that have been taken to remove them.

In the case of the first of these difficulties the remedial measure is obvious. Of the burdens and hardships entailed by the caste system there can be no doubt, nor is it disputed that the tendency of that system is as a rule hostile to progress and reform. Its existence and its power are, however, a very distinct indication of a method of extension of co-operative effort along the line of least resistance. If members of castes of widely varying social status are enlisted in the ranks of the same society, it is clear that the whole force of the caste system is arrayed against successful effort. It is impossible to believe that a Brahman will become jointly responsible for the debts of a Chamar, or that the influence of a Dhobi will suffice to induce a Thakur to pay up a loan, when the latter has preferred the smiling path of recusancy. It is also impossible to expect satisfactory combination between two persons, one of whom enters the village meeting house in order to attend a general meeting of the society's members, while the

other is bidden to sit in the street below. Where castes of widely varying social standing are enlisted in the same society, it is obvious that equality, which is the mainspring of all co-operative effort, inevitably disappears, and that success cannot result. It is true that there are apparently successful banks in existence where the members are drawn from many and varying castes. Success is in such cases due to the exertions of one or more leading men, who have kept things going in practical independence of the opinions or wishes of the ordinary members.

The classes for whom co-operation holds out the greatest hopes of improvement, both material and educational, are the lower castes. They are at present unable to command the same rates of accommodation as the high caste agriculturist, not because their honesty is less or they are more recusant, but because their individual requirements are smaller in amount. Unless they can be included in the operations of the movement, it must so far be held to be a failure. They cannot be included in societies in which high-caste members are enlisted. They must have societies of their own, restricted to members of the lower castes. It seems, therefore, on all grounds desirable that, in the absence of strong reasons to the contrary, the unit of recruitment should be not the village but the caste within the village. This will of course not always be possible or advisable, but where it is possible, it will probably also be advisable.

The adoption of a system of caste-societies will result in the multiplication of the number of societies required to serve any given area. It will also render it impossible to demand from the village society the standard of account-keeping which is at present demanded. In the case of low-caste societies, it is improbable that account-keeping of any standard can be required. These are difficulties which have to be faced, and which will be considered later, when the Central system is described.

The problem of accounts in village societies of the existing type has been met by the abolition of standard forms of account, and by empowering the Panchayat to keep the accounts in any form which in their opinion best suits the requirements of the institution. This has commonly resulted in the maintenance of the ordinary forms of account of the country, the *rokar bahi*, the *khata bahi* and the *roznamcha*. All that is required on the part of the Registration Department is to see that in the accounts kept up in the village, every item of receipt and every item of expenditure shall find a place. This system is not acceptable to the inspecting staff. It is urged that audit is a difficulty, and the simplicity of audit which was a noticeable feature of the model accounts prepared by Mr. Dupernex is regretted. The difficulty of audit is one which must be faced, but which must also be overcome. If work is

to be continued on existing lines and the movement is to be widespread, as it must be to prove of any practical value, the accounts must be of a nature which the villager can understand. They are kept, not for the auditor, nor for the Collector, nor for the Registrar, but for the people. The society is theirs,—they are responsible for its liabilities. It is only just that they should be permitted to keep the accounts in the manner which they prefer, with the one condition that every item of receipt and expenditure shall find a place and that each man's separate account shall be separately maintained. The remedy for the audit difficulty lies with the auditor. He will have to learn the village system, and the vernacular script. Until he has done so he is not fit for his duties.

For the detailed rules by which the original societies were guided and governed, bye-laws have been substituted. In the model bye-laws which have been prepared for the guidance of the Panchayat, the greatest latitude has intentionally been left to those bodies. The problem to be faced is not one of principle, but one of method; and the method suited to co-operation in the Provinces can only be discovered by experiment. Consequently, every point, which could well be left to the Panchayat for determination, has been left to that body. The terms on which a loan is granted, as to interest and repayment, the objects on which such a loan may be expended, the power to grant extensions, whether on payment of interest or not, all these are matters which are left to the judgment of the local managing committee.

This at once raises the thorny question of unreproductive expenditure. In considering this question it is necessary to bear in mind that the circumstances of this country are very different from those of the countries where co-operative credit had its birth. The problem is unique. The agriculturist of these Provinces has from time immemorial pursued the same rocky financial path. He takes advances from the village money-lender for seed, for cattle, for food between harvests, for the clothing of himself and his family, for the marriage of his son or his daughter, and for the disposal of his dead. His *bania* or village money-lender has as much right in him, according to all the canons of village custom, as he himself has in his occupancy holding. Any departure from this custom of centuries at once creates a suspicion of faithlessness on the part of the borrower, not only in the breast of the money-lender whom he deserts, but in the opinion of his co-villagers. Under normal circumstances and in the absence of pressure, it is incredible that one of the *clientèle* of the village money-lender will go elsewhere than to that money-lender for any of his financial requirements; and it must be said that as long as he remains faithful to the money-lender, the money-lender also remains faithful to him. The *bania* does not refuse accommodation

to his hereditary clients, except under stress of the most abnormal circumstances. Though rejoicing in the name of the village Shylock, the local money-lender is in fact indispensable and on the whole reasonable. The bond which he takes for advances made is more in the nature of an insurance than an instrument to be used to prove a case in Court. It very seldom actually represents the amount of the loan, and as long as the borrower makes no attempt to remove his custom elsewhere, no suit on the basis of the bond need be anticipated. If any of his debtors are, for reasons other than recusancy, unable to pay, they are not pressed, and of the profits of the business, probably the greater portion exists only on paper. In obedience to village custom, the money-lender is bound to advance money in many cases in which he knows that a bad debt is a moral certainty.

If co-operation is to be of any benefit, the society must for its members replace the *bania* not only with advances for seed grain, bullocks and manure but also in their thousand and one other financial requirements. No one will willingly join a society where the benefits are confined to these minor matters, for by so doing he at once cuts his hereditary connection with his money-lender, and cannot, consequently, raise elsewhere than from the society the absolutely necessary accommodation for other expenditure. Until co-operative societies are prepared to replace the *bania* not only with loans for reproductive, but also for legitimate and necessary, but unreproductive, expenditure, they will fail of their ultimate object, which is to extricate the agriculturist from the burden of ancestral and perpetual indebtedness.

It is very generally assumed that this course will result in risky business, and that the cheapness of loans will induce even greater extravagance than at present on festivities connected with marriages, funerals and other domestic and social events. The opposite may be expected to be the case where the loans are granted by co-operative societies to their members. In these societies each and every member of the institution, including the members of the Panchayat, is responsible for all loans granted to members. The Panchayat will, therefore, exercise peculiar care in making loans for unreproductive purposes. It may be that a cultivator will come to the Panchayat and ask for a loan of Rs. 200, wherewith to marry his daughter. The Panchayat knows his social position and his circumstances, and decides that Rs. 50 is an appropriate and safe sum to advance for the purpose, and grants that sum. The cultivator accepts it, goes to his fellow-castemen, and though in his heart rejoicing at the curtailment of his expenditure, he explains that he was prepared to spend the larger sum, but that the Panchayat refused to allow him the accommodation. He thus saves his pocket and his *izzat* at the same time. Had the society been debarred from advancing loans for purposes of

marriage expenditure, the cultivator would probably have obtained the money from the local money-lender at the expense of his connection with co-operative credit, and at an exorbitant rate of interest. He would probably also have carried the burden of debt for the rest of his life, and handed it as a legacy to his successor. On the principle, therefore, that as much as possible should be left to the local committee of management, the objects for which loans may be granted have been left to its determination. The result will be carefully watched, though there is at present no sign that the latitude left to that body will be abused.

The raising of capital to finance co-operative societies has presented no difficulties since the passing of Act X of 1904. The Cawnpore Woollen Mills Company placed a sum of Rs. 10,000 at the disposal of the Registrar, for the purpose of advances to such societies. The rate of interest charged is five per cent., and according to the terms for repayment of principal, the amount shall be repaid in ten equal annual instalments, beginning with the sixth year after the money has been drawn. Besides this, Rs. 5,000 of the advance given by Mr. D. M. Hamilton of Calcutta has fallen to the share of these Provinces. Apart from these two loans, local capital is rapidly becoming available. In the Bulandshahr District, the Organization Society has raised a sum of Rs. 7,000 from the local market at six per cent. In the Banda district, the local *mahajans* are anxious to invest in the district societies at the same rate. It seems very probable that all the permanent capital that may prove necessary for co-operative societies in the near future will be locally obtainable without resort to loans from Government except in special cases. The system of depositing money is also showing signs of growth, and in some districts a fair proportion of the working capital is provided in this form by the members themselves. So common is this habit of deposit becoming, that in a number of the societies recently started, the members have agreed to a compulsory half-yearly deposit, as a condition of membership of the society. These compulsory deposits, which are in the first instance of the nature of fixed deposits for five years, take one of two forms. Either they are calculated on the rent paid by the member, the rate varying in different societies from two pice to one anna per rupee, or they are made in grain at the rate of one or two *pansiris* for every plough in the member's use. In the latter case, the grain is sold by the Panchayat in the open market and the proceeds credited to the account of the members who have made the deposit.

In both cases, the deposits bear interest at the rate of one anna in the rupee per annum. The advantages of such a system of deposit are obvious. In the first place, they are a means of increasing the working capital of the society, and allow of gradual expansion of its operations. They are also

valuable as an effective means of increasing the interest taken by the members in the success of the institution, and of causing them to feel that the society is their own, not a venture started and financed by the Government and dependent on the exertions of officials for existence and success. Probably the most important of all the results which may be anticipated from the system lies in the cultivation of habits of thrift. It may reasonably be hoped that at the conclusion of the initial quinquennial period, the habit of deposit will have grown so strong, and its advantages have become so apparent, that the members will volunteer to continue the custom.

Provision has been made in the model bye-laws that in years of scarcity or crop failure, or in any individual case in which the compulsory deposit would mean hardship to the depositor, the Panchayat shall have the power to remit or postpone the deposit. Where general remission is sanctioned by the Panchayat, the fact must be reported to the Registrar for his information. It is permissible to hope that this provision, while preventing hardship in years of scarcity, will at the same time counteract the temptation to remit in years when general remission is not called for.

The two great problems which at present confront the movement are the illiteracy of the lower castes, for whom co-operation is specially fitted and specially necessary, and the absence, under existing conditions, of any connection between the co-operative credit societies and the joint-stock banks. Efforts have been directed towards the solution of these problems, and a method evolved, which seems to overcome the difficulty in each case. The outlines of this method were originally sketched by Mr. Winter (at present Chief Secretary to the Local Government) in a note dated the 21st June 1902.

The illiteracy of the lower castes is such, that it prevents any possibility of independent societies, owing to the inability of members of such societies to keep their accounts. At the same time it is obvious that the lower castes are not in a position to command sufficient assistance from literate members of castes above them in the social scale. Any scheme by which the lower castes can be admitted to the benefits of co-operative credit must then have as an essential feature the removal of account-keeping from the sphere of the village society. The existing difficulty in bringing village societies into touch with the joint-stock banks chiefly lies not in the want of tangible security, but in the smallness of the amounts with which such societies deal. Even with the most reliable security, it would not be paying business for a joint-stock bank to advance a couple of hundred rupees, repayable in instalments spread over a considerable number of years. If, however, the village societies could be induced to combine for the purpose of taking loans of a considerable amount, there is every reason to believe that it

would be possible for them to obtain such loans from the joint-stock banks at a reasonable rate of interest.

The realization of the above two facts led in the first instance to the experiment of Central Banks, to which village societies were affiliated as branches. There are now five or six such institutions and their branches number some 55 or 60. The process of formation was by fission of certain existing village banks, whose members had been recruited from many castes resident in several villages. The new societies were confined to members of the same or allied castes, and to residents of one village. In this reconstruction, it was inevitable that certain of the members of the original society could not, owing to their caste or residence, be included in any of the newly-formed small societies. To such members, their initial entrance fee was returned, and their connection with the society was severed. The small societies having been formed, the members of their Panchayats, or in cases where the number of societies was considerable, their Sarpanches became *ex-officio* members of a Central Society. The sole duties of this Central Society are to raise money on behalf of, and keep the accounts of, all the affiliated societies. The method of working is simple. When the Central Society is instituted and afterwards once a year at its annual general meeting, the maximum credit to be allowed to each one of the constituent societies is fixed. This amount is recorded. Thereafter the sole duty and responsibility, that rests with the Panchayat of the Central Society with reference to loans, are to see that the amount so fixed is at no time exceeded by any society. With the internal arrangements of the affiliated societies the Panchayat of the Central Society has nothing to do. All applications for loans, and all amounts in repayment, come up to the Central Society through the Panchayats of the affiliated societies, and from the lists of payments, or lists of applications for loans as the case may be, the accountant at the office of the Central Society writes up his cash-book, and the ledger-accounts of the affiliated societies and of the individual members of those societies. No accounts are kept at the offices of the village societies. All that is required there is a list of the members and a list of outstanding loans. The members of the affiliated societies have little difficulty in getting these written up by some friendly literate resident of the village in those cases where there is no literate member of the Society. There seems also to be no difficulty in obtaining the necessary help in the preparation of lists of loans required and of payments for submission to the Central Society. In that society, however, it has been found necessary to employ paid labour for account keeping. The payment in the case of small societies takes the form of an annual gratuity, but when the capital of any Central Society becomes

large and the number of affiliated societies numerous, a whole-time accountant will of necessity be employed upon a regular salary.

The joint and several responsibility of the members of affiliated societies in such a scheme is two-fold. Primarily it extends to the loans due by members of their own affiliated Society. Secondarily it extends to the whole of the obligations of the Central Society. This is of course a necessity, as the members of the Central Society would naturally refuse to undertake the responsibility for the whole of the liabilities of that society as a personal responsibility. They are empowered by the bye-laws to pledge the credit of the societies which they *ex-officio* represent. As a matter of fact the secondary responsibility of the members of affiliated societies would only become a reality in the case of failure of any society to carry out its primary responsibility. This is a very remote contingency, and should it arise, the reserve fund would, in any well-managed institution, suffice to meet the loss incurred through the failure of an affiliated society to perform its obligations.

The above system has been working in the case of one of the districts for the past seven months, and seems to be proving a success. Its advantages are many. In the first place the difficulty of account-keeping in the villages is successfully overcome by the simple method of removing accounts altogether from the duties of the village Panchayat. In the place of ten or fifteen small and struggling societies, in each of which account-keeping has proved or would prove a difficulty, there is one strong society which is in a position to offer remuneration to a competent accountant. This again results in the possibility of recruiting caste societies from the lower castes, among whom literate men are extremely rare. Again it results in a number of petty reserve funds, no one of which is of any real value as an asset of security, being replaced by one large reserve, against which it will in a short time be possible to contract temporary loans where such are necessary. Further, owing to the increase in the amounts required, it is possible for such Central Societies to go to the joint-stock banks with some probability that loans will be granted.

The Central system is in fact only an attempt to induce among societies co-operation of exactly the same nature as at present, in existing societies, obtains among individuals. All the advantages which are so marked in the case of individual combination for credit are still more marked in the case of a combination of societies for the same purpose.

This system is being adopted in the case of town banks which are being started in Allahabad and in Gorakhpur. Instead of dealing with individual members, these banks are about to deal with groups of members,

each of which is a separate society, and inside which each of the members is jointly and severally responsible with each of his fellow-members for the loans granted by the town bank. In this case, however, there is no secondary responsibility. The banks are being started on share capital with limited liability.

One of the most valuable advantages which the system of central and affiliated societies offers is the ease with which the work is extended. As funds become available the number of members of affiliated societies can be increased by recruitment, or new societies can be affiliated. The increase in the volume of account-keeping in such cases is by no means commensurate with the increase in the number of individuals to whom the benefits of co-operative credit extend. All that is requisite is a few more pages in the ledger of the Central Society. In the case of a town bank, when the available funds are more than necessary for the requirements of the town in which it works, it is possible for it to extend its operations by affiliation of small rural societies in the vicinity, or by loan to central or rural societies in the neighbourhood. In course of time it seems probable that the normal district organization will be a co-operative town bank at headquarters, with branches in the Tahsil headquarters and larger towns of the district, and affiliated village societies in a very large number, if not all, of the villages of the district.

Co-operative effort in the United Provinces is not confined to co-operative banking, though in the nature of things this special form is at present the most important. At the present moment there is a most interesting effort, on the part of the silk weavers of Benares, to escape from the clutches of the capitalist merchants who control the trade, and to obtain for themselves the profits which go to the middleman. A society has been formed of which the membership roll runs into thousands, which has for its object the provision of raw material at wholesale prices to the weavers, and which will also give advances on loan to respectable men to enable them to hold the finished product until satisfactory sales can be effected. Details are being worked out. The Society will have share capital, and already some Rs. 50,000 have been promised by the weavers. The danger which has to be avoided is premature struggle with the body which at present controls the market. If the Society at first confines its efforts to the provision of material at the cheapest rates possible, and to provision of cheap credit to deserving workmen, much will have been done. Later as it gains strength and accumulates funds, it will be in a position to take over the distribution of the finished product. Its initial financial position will not justify any such attempt at the present time.

Preliminary steps are being taken for the formation of a co-operative seed depôt in the Sultanpur district. Such a society would be highly popular, and could be run with success. Its initiation has been retarded by the abnormal rise in the price of grain owing to the frost in January and February last and the unpropitious character of the monsoon.

There are other forms of co-operative effort which will doubtless be attempted in the near future. The form that co-operation may take is however of secondary moment. Once co-operation in any form is a success the people may be trusted to work out other forms for themselves. The agriculturist of these Provinces has never shown himself slow to adopt any improvement which is workable and valuable, and it is not to be expected that he will be slow to adopt the principles of co-operation, once they are proved by experiment to be successful in any one direction. That these principles are sound is undoubted, and their ultimate general adoption is simply a matter of time and of careful and systematic education. The methods best suited to the conditions of the country will be ascertained by the people for whose benefit the present attempt is being made. And once the principles are known and the method of their application ascertained, a new era will dawn for the agriculturist, and for the lower classes generally.

PLATE XIV

THE BOARD OF AGRICULTURE, PUSA, JANUARY, 1906.

THE SECOND ANNUAL MEETING OF THE BOARD OF AGRICULTURE.

By E. J. BUTLER, M.B., F.L.S.,

Secretary to the Board.

The Second Annual Meeting of the Board of Agriculture took place at Pusa on January the 15th, 1906, and the following days, under the presidency of Mr. F. G. Sly, I.C.S., Officiating Inspector-General of Agriculture in India. The Board was attended by the members of the Imperial Department of Agriculture, representatives of all the Provincial Departments of Agriculture, excepting Burma, and of the Agricultural Departments of Mysore and Baroda, the Inspector-General of the Civil Veterinary Department, the Superintendent, Civil Veterinary Department, Bengal, the Director, Botanical Survey of India, and the Scientific Officer to the Indian Tea Association. The increase in the number of members (thirty-five in all) indicates the progress that is being made in the recruitment of the Scientific Staff of the Departments of Agriculture.

In his opening address the President described the action which had been taken on the recommendations of the Board in the preceding year. Of these recommendations the most important were the strengthening of agricultural staffs in India and the provision for publications by which the work of the departments should be made accessible to the public. At the first meeting of the Board, the difficulty of framing a definite policy of agricultural improvement and experiment in view of the scarcity of specialists available for the supervision of the work was acutely felt. Recommendations were made for the employment of additional staff in several of the more backward provinces and for the appointment of a number of special crop experts to deal with the problems presented by the more important crops of the country. Those which were particularly indicated were cotton, wheat, rice, jute, sugarcane, tobacco and fruit. The large provision for agricultural development announced in the last budget marks the first step in this direction. The Government of India have recommended to the Secretary of

State the creation of permanent posts for crop experts in cotton, wheat, tobacco, jute, indigo and sugarcane, as being the crops most likely to repay immediate investigation. The provincial agricultural departments have been, and are being, strengthened, and arrangements made for the founding of a Central Agricultural College and Experiment Station in every province. At these head-quarters a group of agriculturists and other scientific officers will work, while a number of subsidiary experimental and demonstration farms will be provided for every representative agricultural tract, in which the special agricultural conditions of each will be studied and the results of the work brought home to the cultivators. Thus for the first time in the agricultural history of the country a large and systematic attempt has been made to develop and improve, by the applications of science, its great industry under conditions which promise to be permanent and therefore ultimately successful. The agricultural publications of the past were severely criticised at the first meeting of the Board. As a result of its recommendations a considerable development in this very important matter has taken place. The issue by the Pusa Institute of the "Agricultural Journal," and of "Memoirs" for more scientific work, has been sanctioned by Government as an experiment for a period of three years. In the provinces arrangements for publishing the results of work accomplished on the experimental farms in a compact and easily accessible form have met with general approval. As at present suggested there will be an annual administration report of the provincial department which will contain an account of the general nature of the work which is being done. In addition, each experimental farm will distribute a more detailed account of its work to agricultural officers and others interested in experimental work. Finally, when a definite result has become established from a series of experiments, a separate bulletin containing a complete account of the work with its result will be published for general information. Work of other than local interest carried out in any part of the country will always find a medium for wide circulation in the Agricultural Journal.

In a number of other directions the recommendations of the first Board have been fruitful of results. Efforts towards the extension and improvement of Indian cotton, by hybridisation, selection and the introduction of new varieties into cultivation in India, have made considerable progress. In this Bombay has led the way. The introduction of Egyptian cotton into Sind and the hybridisation work elsewhere have already given much promise of future success. The question of extending jute cultivation outside Bengal is being fully investigated. In almost every other case the proposals of the first meeting of the Board have met with a favourable response.

The real business of the Board, which occupied the remainder of the meeting, included the framing of a standard curriculum for agricultural colleges, a review of the programmes of the departments of agriculture, discussions on the steps to be taken for the improvement of Indian wheat and tobacco, the use of commercial fertilisers in India and veterinary matters.

Sub-committees of the Board were appointed to prepare syllabuses in the principal branches of agricultural education. These were then correlated into a general curriculum for a course of three years' instruction. A feature of these syllabuses (which are published at length in the proceedings of the Board) is the value which is attached to practical instruction in the laboratory and in the field in addition to class-room lectures. The cultivation by individual students of plots on the college farm from an early stage is advocated, and also the training of the students from the very beginning in the ordinary processes of farming as practised on the farm. In the chemistry course the object in view is to bring the students into close contact in the laboratory with such matters as are directly related to agriculture. Qualitative and quantitative analyses are subordinated and the practical study of the properties of typical substances and their quantitative preparation substituted. Similarly in botany, entomology and veterinary science, practical work is given a prominent place all through the course. The object which is aimed at is to turn out students with such a general knowledge of agriculture in its main lines as will fit them for upper subordinate posts in agricultural departments, managerships of Court of Wards and private estates and similar positions. The conferring of a degree in agriculture of as far as possible, uniform value, to be recognised as equivalent to the B. A. degree, was further recommended.

The programmes submitted by members of the Imperial Department of Agriculture and by the different provinces were discussed at length. Arising out of this discussion the Board considered the lines of experimental and research work at Pusa. A sub-committee consisting of the Pusa staff and a number of the scientific and expert members of the Board drew up a memorandum in which the policy which they held should underlie the permanent experimental work of the Pusa Institute was outlined. In this memorandum the view is expressed that from the imperial character of the Institute the work should be of a broader and more fundamental nature than is usually carried on at agricultural experiment stations. The investigations should be devoted to general fundamental principles applicable to tropical and sub-tropical agriculture as a whole, and not be of merely local value. The latter should more properly be carried out at the local experimental farms in different parts of the country. The value of the former

class of work in scientific agriculture is brilliantly shown by the example of Rothamsted in England, where possibly the most instructive series of agricultural experiments ever devised have been carried out. Little or nothing has been done in tropical countries of similar scope. Pusa provides an opportunity for this work, and it will be possible to carry out investigations into the principles of tropical agricultural practice under conditions which provide for continuity and adequate supervision. Pusa will naturally be expected to undertake work of this sort, the provincial farms being in a position to carry on more detailed experiments of direct utility to local agriculture.

As indicating the direction which the experiments at Pusa are likely at present to take, the following may be mentioned. In Agricultural Chemistry plant nutrition investigations, particularly regarding the mode of transmission of food to the plant, including such enquiries as the movements of soil water, the availability of phosphate and potash in soils, and other large problems. In Botany the study of the principles which underlie plant breeding and plant improvement in India, permanent experiments in fruit culture, fibres and similar matters. In Mycology the investigation of soil fungi and their influence on plant nutrition and soils, and the study of specific plant diseases with a view to determining the *causes* which underlie parasitic attack and the *result* on the plant. In Entomology a general survey of the insect pests of the country and a study of the conditions of climate, soil and other factors governing their distribution and prevalence. In Bacteriology the influence of soil bacteria on plant nutrition in the tropics, the decay and fermentation of organic manures, soil inoculation with bacteria, fermentation processes in agriculture and the applications of bacteriology to the investigation of the method of plant nutrition in Indian soils. In addition to these main investigations there will necessarily be a considerable number of enquiries referred to Pusa from all parts of the country, soils, manures, food and oil cakes for analysis and report, botanical enquiries of various kinds, crop diseases and pests for identification and recommendations for treatment. Many of these less fundamental problems can gradually be dealt with by the provincial departments themselves, but particularly in the biological sciences Pusa will have to be in a position to advise and assist other workers in India, since it is at Pusa alone that the knowledge of the conditions prevailing in every part of the country can be concentrated and that collections permitting of the identification of agriculturally important plants and insects for the whole of India can be accumulated.

In considering the programmes of provincial departments of agriculture, some general principles were suggested by the Board as useful in laying

out farms and arranging their work. It is recommended that in farms attached to colleges the teaching portion of the farm should be kept quite distinct from the experimental. Other farms should be founded, each with some definite object in view in improving the agriculture of its particular tract. In some the object will be the study of a particular crop. A number of farms of this nature have already been started, such as those devoted to sugarcane at Samalkota in Madras, pepper at Taliperamba and ground-nut at Palur in the same province, tobacco at Rangpur in Bengal, tropical fruits and spices at Wahjain in the Khasi hills and others. In some, general problems connected with changes of cultivation or crops, irrigation, the reclaiming of bad lands and similar matters are more important. Seed raising is certain to be a very important branch of the activities of most departments, and this will require separate seed farms, some of which are already in existence. Demonstration work is another distinct section, one of the most important of all when the work begins to yield definite results, and separate demonstration plots, probably in large numbers, will be needed. In experimental farms the question of procuring greater efficiency and rapidity of tillage, and associated with this the improvement of work cattle and of cattle fodder, should be an important line of work. The sites for farms require to be selected with considerable care and to be tested by uniform cultivation to learn their peculiarities and to judge of their suitability for experimental work.

An account of the multifarious activities of the provincial departments of agriculture as submitted to the criticisms of the Board would take up far too much space to describe in this article. They may be found in detail in the proceedings of the Board and the reports of the departments. The mere enumeration of the work in hand with sometimes a very brief description of its nature occupies nearly twenty pages of an appendix to the Proceedings. One lesson has, however, been learnt in the past—that it is useless to attempt a large programme of work with an inadequate staff. The very attempt defeats itself, for supervision becomes impossible and the energies of the department become distributed over such a large field that little is ever really finished. A tendency to cut down work to a manageable size has become visible and will probably continue until the departments are better equipped. There is no doubt that this is a healthy sign of the more business-like spirit which has been infused into the work of agricultural improvement in recent times.

Certain general lines of agricultural work are prominent in the programmes of the more advanced provinces. In Bombay, Madras and the United Provinces for instance the study of individual crops has been

undertaken, in each case from the same general standpoint. The crops include sorghum, wheat, cotton, sugarcane, ground-nut, poppy and others. In each the first stage is the working out of the varieties grown in the provinces concerned, including a botanical classification, the determination of their agricultural characters and of their merits or defects and any other points of importance which may occur. In this way accounts of wheat and cotton have recently been published in Bombay, of sorghum in Madras and of sugarcane in the United Provinces. It is recognised that a reliable knowledge of the existing varieties is a necessary preliminary to much of the work of improvement.

Beyond this point the enquiries have not as yet progressed to any extent except in the case of cotton. But the further work which has been undertaken in the latter is probably an indication of what will be eventually done for many of the principal crops of the country. This work has been chiefly in the following directions. First an attempt is made by hybridisation and selection to produce new varieties or to improve existing ones so that each climatic area may obtain a plant better suited to its needs than those already cultivated. In this, of course, attention is largely given to the class of lint produced by the new or improved variety. But it is becoming more and more recognised that in the economic state of the ryot it is useless to provide a superior staple unless the conditions which govern its suitability from his point of view, such as its hardiness, ease of cultivation, resistance to drought and cold are carefully borne in mind. It is useless to introduce a long-stapled cotton to replace a shorter, if the former is more troublesome to grow, less hardy, more liable to risk of loss in an unfavourable season and therefore in the long run less profitable to the cultivator. A larger profit does not in India, as it does often elsewhere, compensate for a greater risk, for it is only rarely that the cultivator has a reserve to fall back on. A second direction in which an attempt is being made to improve Indian cotton growing is so to alter local cultivation as to enable a more profitable variety to be grown or to improve the yield of an existing one. In some parts, for instance, cotton is being sown with irrigation before the rains, as by this means it is hoped that the better class of cottons may mature in Northern India before the cold season arrests growth.

Besides these two lines of work which can only be undertaken when a knowledge of the agricultural varieties of each province has been gained, there are several other directions in which improvement is being aimed at Seed selection and distribution is one of these. In the districts of Dharwar and Ahmedabad, cotton seed selected from the fields of cultivators sufficient to sow 11,500 acres was distributed by the Bombay department last year.

In several other provinces similar field selection of cotton seed has been undertaken. Seed of good varieties obtained in one part of the province has also been distributed to districts, where an inferior variety is grown. This has been done with a number of other crops, such as wheat, sorghum, and paddy, and one of the most successful of these attempts has been the introduction of Mozuffernagar wheat into the Eastern portions of the United Provinces. The trial of exotics, while not as a rule offering the same promise as the improvement of indigenous kinds, has in some cases been successful. In Sind some six thousand acres will be sown with Egyptian *Abassi* cotton this year, as this variety has proved suitable for irrigated lands and gives a good yield of lint, which has been valued at twice as much as the local kinds. Perennial cottons, both Indian and exotic, are being experimentally grown in several localities. Experiments in manuring cotton are in progress at a number of Government farms. Demonstrations of improved methods of cultivation for cotton have been made in backward parts of the Central Provinces and elsewhere.

The above is a summary gathered from the programmes of work of the departments of agriculture submitted to the Board, of the lines on which the improvement of a specific crop, cotton, is being attempted in India. What is being tried with cotton has commenced with several other crops, and eventually we may hope to see a number of the chief crops of the country systematically dealt with, and the direction in which improvement can be carried out determined. With two, wheat and tobacco, the Board have, in fact, drawn up a definite scheme for future work in view of the expected appointment of special wheat and tobacco experts.

The improvement of Indian wheat was considered largely from the point of view of the export trade. This has recently reached very large proportions, India having supplied more wheat to the United Kingdom in 1904-5 than any other country. Most of this wheat is used for bread making. No reliable milling and baking tests have, however, as yet been carried out, and the relative value of the varieties cultivated and the manner in which they compare with other wheats imported into the United Kingdom as bread-makers is not known. A survey of the varieties cultivated has been made in only a small part of the country, and this is the first step in the improvement of any crop. Indian wheats are often mixed, and a mixed wheat is unsatisfactory from the miller's point of view. There are difficulties connected with adulteration, storage, transport and other matters, all of which interfere with the export trade. As a result of the consideration of these points the Board adopted a scheme for future work, which should be a useful indication of the matters to which attention should be directed. They

suggest that in the first place a reliable survey of the varieties cultivated in each province should be made. This should include the general agricultural characters of the varieties, their distribution as regards area and type of soil, rust and drought resisting power, and suitability of the grain for local use and for export. In the second place milling and baking tests of the chief varieties should be made. Whether these should be carried out in a laboratory specially equipped for the purpose in India or should be done in England was left over for future consideration after the appointment of the wheat expert. Next the growth of pure varieties and the export of pure samples should be encouraged. The storage question should also be enquired into. Adulteration and transport difficulties are considered to be primarily matters to be dealt with by the trade. Finally a number of experiments, including the production of new varieties suitable for definite areas, introduction into cultivation of rust-resisting and drought-resisting wheats, seed distribution, rotation and other cultivation experiments and the like, are indicated.

In the same way a scheme was proposed for future work in the improvement of Indian tobacco. Certain areas are specified in which work may be most advantageously commenced. In these the existing methods of tobacco cultivation and curing should be enquired into, particularly with a view to ascertain the causes of the very different qualities of tobacco produced at different gardens. This enquiry should be supplemented by an investigation of tobacco soils and of the well waters used in irrigating tobacco to which the cultivators attach so much value. A comparative survey of the varieties should be carried out on the lines mentioned above in the cases of cotton and wheat. Experiments should be made in cultivation, methods of harvesting and methods of curing, especially the latter which offers the largest field for experimental work with the greatest possibilities of improvement. The trial of exotics should be one of the important lines of work. It is not considered that there is much scope for improvement in the production of tobacco in the form usually consumed by natives of India except by increase of yield, the main possibilities lying in the production of cigar, cigarette and pipe tobaccos.

Another subject which was considered by the Board was the use of commercial fertilisers in India. In some parts of India the time has arrived when there is a prospect of introducing this class of manures with good results. There is, however, often a difficulty in obtaining fertilisers of guaranteed quality. Suggestions for legislation for the inspection and control of commercial fertilisers were made and information concerning the systems in force in other countries was given. The Board resolved to appoint a committee to investigate the whole question and report to the next meeting, when the advisability of recommending legislation would be considered.

Many matters connected with agricultural stock and veterinary subjects were on the agenda sheet. Amongst these was the danger of restricting cattle-breeding by the curtailment of grazing grounds both by increased irrigation facilities, which have led to large areas being devoted to arable cultivation without any provision for grazing, and by closing forest reserves. A second matter was the consideration of the best method of employing the services of veterinary assistants, whether by stationing them at fixed headquarters or making them travel about their district. The provision of fodder in times of famine was also brought up for discussion. The Board decided that the issues raised by these questions are so large and the time given to consider them so limited that they should be deferred until the next meeting. The Government of India will be asked to request local Governments to collect information which will then be distributed to members well in advance of the meeting.

Before breaking up, the Board adopted some suggestions made by the President regarding the procedure to be followed in preparing the subjects for discussion at the annual meetings. It was agreed that the main subjects should be decided on as far as possible at the close of the preceding meeting in order to give members time to prepare the materials necessary for a full consideration of each. For next year the following programme was recommended : the confirmation of the proceedings of the last meeting ; consideration of the programmes of the Imperial and Provincial Departments of Agriculture ; a discussion on the improvement of sugarcane ; and the subjects referred over from the last meeting. Other subjects are likely to arise during the year. Finally it was decided to recommend to the Government of India that the meetings should be held alternately at Pusa and in the provinces, and it was suggested, at the invitation of the United Provinces Department, that the next meeting should be held at Cawnpore.

The above account will give some idea of the nature of the work done by the Board of Agriculture, and all its members feel that the annual meeting is a most useful institution, which affords an opportunity to the agricultural staff scattered throughout India of discussing their problems with each other, of correlating their work and of benefiting by hearing the views of others working for the same great object—the improvement of Indian agriculture.

AN EXPERIMENT IN THE ERADICATION OF THE KANS WEED

By E. BATCHELOR, I.C.S.,

Asst. Commissioner, Saugor, Central Provinces.

THE weed, generally known as *kans* (*Saccharum spontaneum*) is one of the worst enemies of the cultivator in some parts of India. It is most common in the black soil tracts in the centre of peninsular India, comprising the Bundelkhand division of the United Provinces, portions of Central India and the northern districts of the Central Provinces. In this tract it infests hundreds of thousands of acres of good culturable land ; indeed it is most prevalent in the richest soils. Under normal conditions, the ryot is able to keep this weed in check by the very careful tillage constantly given throughout the monsoon period to land destined to be sown with a rabi crop towards the close of the rains, but this careful tillage cannot be given in exceptionally dry and exceptionally wet years. Its rapid spread has been one of the very worst incidents of the series of dry years which have characterized the past decade, for its presence has not only caused much of the land which could not be properly cultivated or sown on account of short rainfall to lie fallow, but what is worse, it has made the reclamation of such land so expensive that very large areas indeed have been abandoned and allowed to remain waste till the weed dies a natural death, a relief which comes to the cultivator not earlier than after a dozen years. In such land the weed forms a dense matted mass of roots in the soil, which prevents its tillage by a cultivator who does not possess exceptionally good bullocks, strong ploughs and ample means to bear the heavy expense involved.

My first practical acquaintance with the subject was in 1901 when I was posted to the Saugor district of the Central Provinces, which contains one of the very worst of the tracts affected by the presence of the grass. I was then told of several experiments which had been made by Government in order to ascertain whether the grass could be cheaply eradicated. Some land was broken up with foreign iron ploughs, and in other plots the

weed was dug up by hand labour. The great cost of the latter method makes it quite uneconomical except in very special cases and precludes its adoption except by the richest; however the curious part of my information was that the labour was absolutely thrown away, as the grass continued to grow after the land had been hand-dug. I can scarcely believe that such would have been the case had the land been cultivated in the ordinary manner after the weed had been dug out. The first mentioned method, *i.e.* ploughing with iron ploughs, was unsuitable for general adoption, for the people said it was beyond the power of their cattle, and also of their ploughmen. As both experiments were failures, and as it was the Government which had carried them out, the result was to strengthen the people in their conviction that it was useless to attempt the eradication of the weed; and I found recently when visiting Khurai in order to make an experiment with the instrument described later on that the very best of the cultivators still entertain this fatalistic idea. A third method that has been tried is the embankment of land so as to keep it under water throughout the monsoon rains. This method is reported to have met with some success, but it is obviously applicable only to fields which are favourably situated for flooding, and moreover the expense of embankments is heavy. In December 1901, I was transferred to Hoshangabad where the *kans* weed was almost as bad as Khurai, and where in great measure as a consequence of its presence the land revenue had just been considerably abated, and where some of the most famous villages of the district had become almost a wilderness of *kans*. Indeed in the Central Provinces alone, the presence of *kans* has caused, and will cause for many years to come, an annual loss of many lakhs of rupees, both to the cultivators and to Government.

It occurred to me that to a large extent the failure of methods hitherto tried might be due to fact that too much had been attempted at once, and that better results might be obtained by effecting the eradication of the weed by an operation distinct from that of breaking up the soil. The common plough is made as large as it is possible for the ordinary bullock to work, and hence if to the resistance of the soil is added that of the roots, which is very large indeed where the *kans* is thick, the result must be that the plough cannot work at all deeply, and as the roots run at all angles, the land must be ploughed very many times before the plough can get deep enough to produce a tilth suitable for sowing. Further, as the point of the plough is smooth, the root is severed in a very uneconomical way. I, therefore, came to the conclusion that what was required was something thin with a sharp edge. This would, by cutting the roots into suitable lengths, get rid of the resistance caused by their great tensile strength and allow them to be cut

without greatly disturbing the soil: the latter was left for a subsequent operation. After several experiments with various kinds of instruments fitted first to the hoe (*bakhar*) and then to the plough in different ways, I came to the conclusion that a thin vertical blade fixed in the plane of the body of the plough and with its cutting edge set at an angle of about 20 degrees to the horizontal gave the best results. The sketch below shows the size of the blade and the manner of its attachment to the plough.

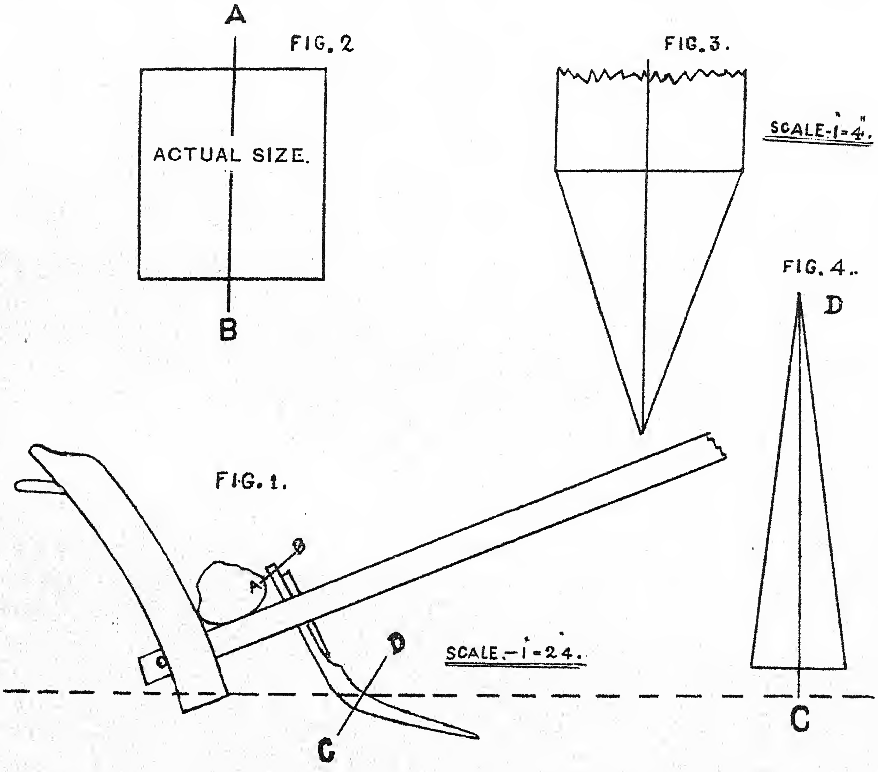


Diagram of the blade used to cut the *Kans* roots.
Fig. 1. Side elevation. Scale 1 in 24. The dotted line shows the ground level.
Fig. 2. Section of blade on A—B. Actual size.
Fig. 3. Front elevation of the lower part of the plough-tail. Scale 1 in 4.
Fig. 4. Section of blade on C—D. Actual size.

The blade is about 15 inches long and tapers to a point from a width and breadth of 2 inches and ½ inch respectively. I have found it most convenient to attach it to the beam of the plough, but it may give as good results if otherwise attached.

Having decided on the make and use of the instrument, a beginning was made in the first week of August 1902 with an experiment in the worst piece of the kans fallow which I could find in the vicinity, and in this plot

the grass was nearly as thick as it is ever found. The bullocks used were above the average of those owned by the ordinary tenants, but not above the average of those used by landed proprietors. The land was ploughed first and then cross ploughed with the blade so as to cut the soil into squares about one foot in size, and was afterwards ploughed once with the ordinary plough. I was then under the impression that the work of eradication must be thorough if re-growth was to be prevented, and for these reasons the roots were grubbed up with an instrument specially designed for the purpose from an ordinary *bakhar* (paring plough), and a sketch of which is shown below. This instrument was used in the same manner as the blade, i.e., there were two operations, one being at right angles to the other.

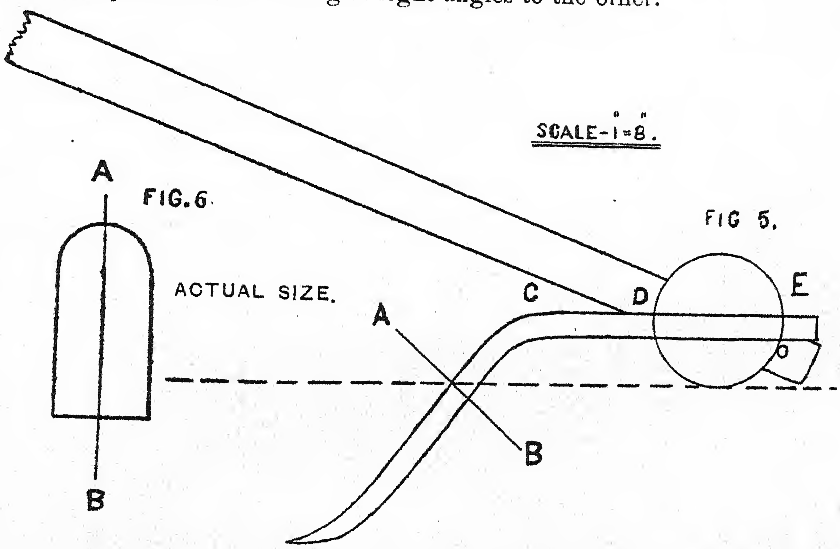


Diagram of the grubber.

Fig. 5. Side elevation. Scale 1 in 8. The dotted line shows the ground level.

Fig. 6. Section of iron on A—B. There were two such bars about ten inches apart. Actual size.

I now consider, however, that this instrument was somewhat beyond the power of the bullocks, and consequently do not recommend its use for this purpose. The roots were then collected by hand labour, not because there is any necessity to do so, but because the heap of weeds was an excellent object lesson. And in order to prevent the eradication of unsevered roots, I gave strict injunction that only the slightest amount of force should be used in collecting the roots. However, as just mentioned, this collection is in my opinion unnecessary and none such was made either in the experiments at Hoshangabad in 1904 and 1905 or in the experiment which I personally supervised at Khurai in 1905. The land was twice *bakhared* with the ordinary paring hoe once in August and

once late in September, and sown half with gram and the other half with wheat, the latter more out of curiosity than as an experiment. The crops were cut and thrashed in my presence, and the outturn was at the rate of 1160 lbs. per acre for gram and 370 for wheat : the former is double the standard outturn for the district and quite 60 per cent. above that for the soils concerned. The season was, however, a favourable one, in which the yield of gram grown in ordinary land of similar quality may be estimated at 800-900 lbs. per acre. From timing experiments made, I came to the conclusion that quite seven to eight acres could be broken up from fallow with one pair of bullocks in one working season. The operations were repeated in 1903 in the same spot during my absence in England, with the result that the *kans* absolutely disappeared and a normal crop of wheat was raised.

Mr. Mollison, Inspector-General of Agriculture, and Mr. Sly, then Director of Agriculture in the Central Provinces, paid a visit to the plot in September 1902, whilst the experiments were in progress, and as a result it was decided to make comparative experiments to test the respective merits of this instrument, and the country and iron ploughs for *kans* eradication. The experiments were made in 1904-05 on the Hoshangabad Government Experimental Farm, which is situated at a distance of about one mile from the locality where the experiments just mentioned were conducted. In the plot reserved for experiment with my instrument, a ploughing and cross ploughing were given with the blade, after which two hoeings were the only operations previous to sowing. The crop sown was gram and the outturns obtained were 239 lbs. per acre in the case of the Swedish iron plough, 258 lbs. with the country plough and 381 lbs. with my instrument. The cost of the operations has been given at Rs. 7-2-9, Rs. 6-12-6 and Rs. 7-15-6 per acre respectively, as compared with Rs. 4-13-0 in ordinary land. In this calculation the value of the labour of a pair of bullocks is put at 12 annas a day.

The outturns may appear at the first sight to be very different from those I obtained. The year 1904-05, however, was a bad one for crop yield, as the rainfall was much below the normal and the crop suffered from frost, and the outturns in the only three plots of ordinary cultivated land sown with gram were 265, 312 and 359 lbs. per acre respectively. The average of these is 310 lbs., and it will thus be seen that the outturn obtained in the *kans* plots treated with my plough was nearly 25 per cent. better than the average in ordinary land and was greater than that in the best of the three plots. More labour was spent on the land by me than in the case of the experiments at the Government Farm and hence it would appear that the two results are mutually confirmatory. I have myself

this year conducted experiments at Khurai in the worst field of *kans* fallow which could be shown to me in the vicinity, and the latest reports received are to the effect that the gram is better in that plot than in the ordinary land, which helps to confirm the results obtained in the two previous experiments. I think that the rainfall of the year 1902 was, if anything, unfavourable for the experiments. As above stated, the experiments began in the first week of August, and were practically finished by the third week of that month; there were no field operations thereafter till the end of September. Only 1·03 inch of rain was registered in the last 11 days of July, and ·50 inch in the first 17 days of August; fairly heavy rain then commenced, and in all 10·71 inches were registered in the month as compared with a normal of 13·43 inches. The rainfall recorded at each of the two nearest rainfall recording stations was above the normal. In September the rain practically ceased on the 21st, when 6·89 inches had been registered as against a normal for the whole month of 9·54 inches; the rainfall in this period of 21 days was thus about 1½ inch below the normal. For the period August 18th to September 21st, the rainfall was 17·60 inches as compared with a normal of about 12 inches. It will thus be seen that at the beginning of the experiments the ground was somewhat too hard for the effective working of the blade, and that after the second week of August the rainfall was favourable to the re-growth of the severed roots. In 1903 the rainfall was practically equal to the normal; and in 1904 it was considerably below the normal. It is possible, however, that in an exceptionally wet year, severed roots might grow to such an extent as to make eradication by a hoe not altogether effective, but an additional ploughing with the ordinary plough would then be necessary and sufficient.

So far as the experiments have proceeded, they appear to show clearly that the use of the instrument now under notice gives far better results than can be obtained by the use of the country or iron plough. The instrument can be worked with even less draught power than is required for the ordinary plough and its price, which is from Rs. 2 to Rs. 3 according to the quality of the material used, places it within the power of the poorest tenant; it can be sharpened and adjusted by the ordinary village artisans. The arguments usually adduced against new instruments have, therefore, in this case no validity.

It remains to be considered to what extent the demonstration of the advantages attending its use are likely to lead to its adoption by the ordinary cultivator. I must confess that my acquaintance with the considerations determining the kind and extent of the various field operations is insufficient to induce me to give a general answer to this

question ; were information available which would enable one to say to what extent the land suffers by being deprived of one of the usual operations, it might be possible to give an answer and thus to calculate the value of the time which is devoted to the breaking up of *kans* fallow, when this is effected at the expense of ordinary field operations, but even so it would be so general as perhaps to be of little use. Then, again, although it may theoretically be advisable to forego a little in the present in order to reap a larger harvest in the next and following years, I fear the ryot who works with an eye to the future is an exceptional man, and perhaps the ordinary man is wise in concentrating his attention on the current year ; the last decade has shown that a large reserve is desirable even if no experiments are tried. Details which I have kept of the experiments made in 1902 and those furnished to me by the Superintendent of the Hoshangabad Government Farm point to the conclusion that it will pay a fairly well-to-do man in a normal year to devote a pair of bullocks to the cultivation of nothing but *kans* fallow, and I am strongly inclined to believe that the ordinary cultivator could in a normal year make a profit from a holding of nothing but *kans* fallow, by the use of the instrument described. It is, I think, certain that with the ordinary plough the cultivation of *kans* fallow is conducted at a loss so far as the first year is concerned, whether the cultivation is prosecuted as a separate operation, or at the expense of other land already in cultivation.

Although it may be possible, by recording the amount of labour expended in the breaking up any particular area of *kans* fallow, and by comparing this with the number of days on which cultivating operations in fallow land is feasible, to estimate the area which could be broken up by one pair of bullocks specially reserved for the purpose, and thus to ascertain the financial result of the operations, I do not consider that this is sufficient to convince the ryot of the advantages of the method, as he will admit the crop is good, but object that the amount of labour is so excessive as to debar him from imitating it. It appears to me that the best method will be to reserve a pair of bullocks specially for the purpose of breaking up *kans* fallow, and thus to demonstrate to the full what can be effected by the use of the instrument. The cultivator will then be able to draw his own conclusion as to the financial result of the cultivation and decide to what extent it is advisable for him to copy it. If the results prove the operation is profitable, I can think of no better method of carrying conviction. I trust that it may be found possible to conduct experiments on these lines in all districts where the presence of *kans* is as heavy a burden on agriculture as it is in this district.

CONDITIONS OF SERVICE IN THE AGRICULTURAL DEPARTMENTS OF INDIA.

An article in our first issue gave an account of the present constitution of the Agricultural Departments of India and of the proposals for their expansion, which showed that a considerable increase in the staff of specialists is contemplated. We now publish a memorandum containing the terms of employment in the higher appointments of the Indian Agricultural Service. It is anticipated that these terms will secure for India the best of the young scientists of the English Universities and Colleges. The plan of recruiting a supernumerary staff of young men, who have just completed their College course and who will undergo a further training under Indian conditions at the Pusa Research Institute, will also help to remove some of the difficulties that now exist in securing qualified candidates of mature experience. It is hoped that in time some of the best students of the Pusa Agricultural College will ultimately be qualified to fill a proportion of the higher posts of the service.

APPOINTMENTS IN THE INDIAN AGRICULTURAL SERVICE.

1. The appointments in the Indian Agricultural Service include those of Deputy Director of Agriculture, Superintendent of Government Farms, Agricultural Chemist, Economic Botanist, Mycologist, Entomologist, Professors of Agriculture, Chemistry and Botany at Agricultural Colleges, and the like. Some of these are included in the Imperial Department of Agriculture under the direct control of the Government of India, but the majority are included in the Departments of Agriculture of the several provinces of India. In some cases candidates will be appointed direct to these posts, but in most cases they will be appointed as supernumeraries, will undergo a further course of training in India in Indian agriculture, and will be appointed to posts on the regular establishment as vacancies occur.

2. Appointments are made by the Secretary of State for India as occasion may require, and applications regarding them should be addressed to the Revenue Secretary, India Office, London, S. W.

3. Candidates must, as a rule, be not less than 23 nor more than 30 years of age. Exceptions will be made as regards the maximum limit only in the case of appointments requiring special qualifications. Candidates must furnish evidence of having received a good general education, and of possessing a thorough knowledge of the science of agriculture or of the particular science required for the appointment applied for. Preference is given to British-born subjects and to distinguished graduates of some University in the British Empire.

4. Applications should be submitted upon the form provided for the purpose and should be accompanied by testimonials setting forth fully the candidate's personal and professional qualifications and practical experience.

5. Candidates whose applications are selected for consideration will be required to present themselves for an interview with an official at the India Office. In selecting candidates for appointment weight will be given to the possession of (*a*) a University degree in honours in science or the diploma of a recognised school of agriculture, or other like distinction ; (*b*) qualifications in a special science according to the nature of the vacancy to be filled ; (*c*) practical experience. Importance is also attached to bodily activity and ability to ride, and selected candidates have to undergo an examination by the Medical Board of the India Office as to their physical fitness for service in India.

6. Newly appointed officers are required, before leaving this country, to enter into an agreement with the Secretary of State embodying the conditions of their appointment. They are also required to leave for India within three months of their appointment by the Secretary of State, and are provided at the expense of Government with a first-class passage to India, the cost of which they will be required to refund if they voluntarily relinquish the service of Government before the close of three years from the date of appointment. In the event of an officer being compelled by ill-health to give up the service within that period, a first-class passage to England will be provided at the expense of Government. Pay commences from the date of arrival in India.

7. An officer appointed to the Agricultural Service, whether as a supernumerary or otherwise, and whatever his initial salary may be, will be on probation in India for three years, within which time he will have to pass an examination in a vernacular language. His appointment may be cancelled for failure to pass this examination, or at any time for unfitness or misconduct. At the end of his three years' term of probation the Government of India will decide whether to retain or dispense with his services.

8. Officers of the Agricultural Service are expected to give their whole time to the duties of the service, and are liable to transfer from one appointment or province to another.

9. The salary attached to posts in the Indian Agricultural Service will ordinarily be—

	Rs. per mensem.	
For the first year	400	
" second year	430	
" third year	460	
" fourth and subsequent years ...	500	rising by annual increments of Rs. 50 a month to Rs. 1,000 a month.

Candidates who are required to undergo a further course of training in India under paragraph 1 above will be appointed on this scale of salary, commencing on a pay of Rs. 400. Where for special reasons a candidate is recruited for direct appointment to one of the regular posts under paragraph 1, his initial pay will be determined with reference to the special qualifications and the length of European experience required for the appointment for which he is specially selected, but his subsequent increments of salary will be regulated by the foregoing scale.

No exchange compensation allowance will be given, and free quarters will not usually be provided.

10. Members of the Indian Agricultural Service draw travelling allowances for journeys on duty as officers of the first class under the Civil Service Regulations.

11. On being confirmed in his appointment, a probationer will become eligible, as from the date of his arrival in India, for leave allowances and pension, under the provisions of the Civil Service Regulations applicable to the Department. These regulations are liable to be modified by the Government of India from time to time. Copy of an abstract of them will be supplied on application to the Revenue Secretary, India Office, London, S. W.

12. Retirement is ordinarily required at 55 years of age, but an officer may for special reasons be retained after attaining that age.

Form of application for appointment to the Indian Agricultural Service.

1. Candidate's name in full and address; and name, nationality and profession of father.
2. Date of birth (*copy of birth certificate should be attached*).
3. In what School or Schools educated (give dates).

4. Particulars of University career, distinctions and degrees (give dates).

5. Particulars of course of instruction undergone at any special College or Institution (give dates).

6. Particulars of special qualifications, theoretical and practical, for the post applied for.

7. How occupied since completion of course of study (with dates), with full particulars of any practical experience which the candidate may have acquired.

8. Married or unmarried.

9. References (names and addresses). (*Testimonials may be submitted with this application*).

Signature.

Date.

The Candidate should state in this space any further facts, not given above, which he may desire to mention.

NOTES.

THE SELECTION OF PEPPER VINES.—Any one at all conversant with a plantation of black pepper will have noted the great variation in the bearing power of different vines. A special study of this question has recently been undertaken in the Wynaad and Malabar, and some of the results are given below.

Each plantation has been found to consist of a great number of varieties, probably all or nearly all belonging originally to one species. These varieties may be separated by their habit and general appearance at a distance, by the shape and colour of their leaves and lastly, under a lens, by the character of the individual flowers. The flowers of the best varieties are all well supplied with both stamens (the male elements) and ovaries (the female organs). And as a general rule any lack of fertility is due to the absence of one or other of these.

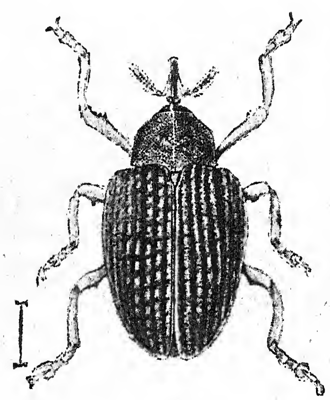
Purely male vines are of rare occurrence. It is not likely that any one would take cuttings from a vine which had never been known to bear, and this would be the character of a purely male vine. Purely female vines, that is to say ones with no stamens at all, are common in the Malabar plantations. Their spikes are formed as usual, but as ripening approaches many of the berries do not swell, this being probably dependent on the nearness of the stamens on some neighbour. In the Wynaad plantations the purely female vines are uncommon, but there are very many which are markedly deficient in stamens. These go by very various names, the sparseness of stamens being usually accompanied by differences in habit and foliage noticeable at a distance.

In choosing vines for propagation it will, therefore, be necessary first to determine whether the plant is fully provided with stamens. This may usually be done by naked-eye observation all through the fruiting season, but it will be safer to use a lens. It may be taken as a rule that any vine, if fully provided with stamens, will give a good crop, while any vine not so provided

will be capricious in its behaviour, being dependent on its neighbours for the swelling of its berries.—(C. A. B.)

* * *

THE MANGO WEEVIL. (*Cryptorhynchus mangiferae.* Fabr).—Among the insect pests of India is the weevil which destroys the fruit of the mango and which obtrudes itself so unpleasantly upon the notice of those who eat this fruit. As yet no method has been found of checking this pest which, whilst most common in Bengal and Assam, appears to be spreading over India and is certainly known from Satara and the neighbourhood of Bombay. It is not confined to India, but also occurs in Natal, Hawaii and probably elsewhere in the tropics.



The grub or weevil is generally found in the fleshy part of the fruit or even eating the stone, the weevil coming out through the flesh ; such a mango is uneatable, but unless the beetle has emerged, there may be no sign of the presence of the grub, the fruit appearing to be sound.

The life history is known to be passed in the fruit, that is the eggs are laid by the weevil in the fruit, the grub hatches from the egg, spends its life within the fruit and emerges as a weevil from the fruit after it has passed through the quiescent pupa state. As mangoes occur only once in the year, and there is but one generation of this pest in each crop, it was of vital interest to know how the weevil lives from one season to another ; how is it that there are weevils ready in the early hot weather to lay eggs on the mango blossoms or young set fruit ? Obviously this is the crux of the question, as there is no means of destroying the grub in the mango without injuring the fruit and no means (except netting the trees) of preventing the beetle having access to the flowers and young fruit. A curious point noted by many observers is that the same tree is affected year after year, even when there are numerous trees close by ; this has given the clue that has settled the point.

If we examine the weevil when it emerges from the fruit, we notice that it is a dark brown beetle, somewhat roughened ; it is not smooth or shiny but dull, unobtrusive and rough ; its habits are extremely sluggish and it clings tightly to anything it may be on. Weevils kept in confinement under observation did nothing, simply lived and slept, some few gradually dying.

Eventually it was found that the weevil's pet haunt is the bark of the mango tree ; its form and colour are such that on mango bark the insect is extremely inconspicuous, and might simply be mistaken for a natural protuberance. When kept on mango bark it simply clings tightly in a cleft or depression and sleeps. It sleeps through the rains and later hot weather until the cold season, when insects become torpid. In a dormant state it remains hibernating through the colder months until the first hot weather wakes it to activity at the time when the mango tree blossoms. Actually the weevils can be found on the trees through this long period, clinging to the bark in a cleft or depression and extremely well hidden by their form and colour. The females alone survive the cold weather, the males dying soon after coupling in the rains. We know so little of how insects pass through the seasons that this life history is not surprising, but it is rare that a life history can be so completely traced and worked out.

Evidently we have here the means of checking the insect ; it normally remains on the tree from whose fruit it hatched, from one mango season till the next mango blossom appears. It is then only necessary to destroy it ; as the simplest way, paint or scrub down the bark with kerosene ; this is best done in the cold weather but can be done at any time before the mango flowers or the beetle becomes active, say not later than the beginning of February. A further precaution is to dig over the ground below the trees, in order to destroy any weevils that come off the bark and take refuge there.

It is to be hoped that those who own mango trees which are infested will take these simple precautions. It will at least protect their trees, and the practice may in time gradually become general and pass into the category of things regularly done as a matter of course, though the reason for them has long been forgotten. The mango weevil will then become extinct, except as a naturalist's curiosity.—(H. M-L.)

* * *

Egyptian Cotton in Sindh.—In former years some spasmodic trials of Egyptian cotton were made in Sindh, but these were not successful ; and it is now recognized that the failure was due to incorrect methods of treatment by officers who had no knowledge of Egyptian cotton cultivation. More recent trials conducted by Mr. M. D. Mackenzie, Deputy Commissioner of the Thar and Parkar District, gave better promise, and in the past two years the Bombay Department of Agriculture has made systematic experiments, the work being undertaken by Mr. F. Fletcher, M.A., B.Sc., Deputy Director of Agriculture, who has experience of Egypt.

A full account of these experiments is given by the Deputy Director in his Annual Report on Experimental Farms for the past year, from which the following details are extracted :—

Name of variety.	Average yield in lb. per acre of seed cotton.	Valuation of fibre in pence per lb.	Compare valuation of Egyptian at the same date.
Yannovitch	881	5*d.* to $7\frac{1}{4}$*d.*	8*d.*
Abassi	846	6*d.* to $6\frac{1}{2}$*d.*	$7\frac{3}{4}$*d.*
Mitaffifi	977	$5\frac{1}{2}$*d.* to $5\frac{1}{2}$*d.*	$6\frac{15}{16}$*d.*
Ashmouni	999	5*d.* to $5\frac{1}{4}$*d.*	$5\frac{5}{8}$*d.*

The regular experiments were started in 1904 on a plot of land taken up temporarily at Dhoronáro on a canal in the Thar and Párkar District.

The Egyptian methods of cultivation were followed in every detail, and the season was not an exceptionally favourable one. The growth of the plants appeared to be normal throughout. The yields were all good for unmanured land, and compare favourably with those obtained in Egypt. The best outturns were secured from the crops sown early in April and the worst from those sown late in June. The staple shows some deterioration, which is greatest in *Mitaffifi* and least in *Yannovitch*, the finest and most delicate of all the Egyptian varieties.

Last year a regular experimental farm was started at Mirpurkhás, and seed was also distributed to selected cultivators for trial under careful supervision by officials of the Department of Agriculture. The total area sown was about 1,500 acres, so that the trial was on a fairly substantial scale. Definite figures of the yield are not yet available, but the trials seem to be almost uniformly successful. The crops on the Government farm are not so good as some of those of cultivators, the land being somewhat below the average in quality and in a foul condition when it was taken up. Some excellent crops with a very heavy yield are being secured in some plots sown by Mr. M. D. Mackenzie, who has given the greatest assistance in this trial. According to the general estimate, the outturn will exceed that obtained last year, and will be larger than the indigenous Sindhi cotton, for which the season has not been very favourable. The lint has yet to be properly valued, but it seems to be quite as good as that of last year. The zamindars, who were reluctant to try Egyptian cotton last year, now speak of it in favourable terms.

In some plots a good deal of damage has been done by bollworm, but this insect pest has ravaged the indigenous cotton to an even greater extent. There is no reason at present to anticipate that it will be a particular pest of Egyptian cotton. Some damage has also been done by white ants, which seem to attack the Egyptian [somewhat more freely than the indigenous cotton. This may be due to the fact that the land is not flooded and does

not receive so much water. The crop from the Egyptian seed produced last year in Sindh seems quite as good as that from newly-imported seed.

The seed distributed to cultivators was all of the *Mitaffiji* variety. This variety was selected before the full valuations of the previous crop could be obtained; and it was chosen because it is a hardy variety in Egypt and because it seemed at the time the most promising variety on the Dhoronáro land. The subsequent valuations showed that it had deteriorated in staple more than the finer varieties, whilst the current year's trials point to *Abassi* as the better crop for Sindh. Arrangements will be made by the Department of Agriculture to call in the seed of the *Mitaffiji* variety and to distribute *Abassi* for the coming year.

The results, so far as they are known, of the year's trials are thus very promising. There are only two years' crops from which to draw conclusions, but unless something untoward develops in the future there is great promise that Egyptian cotton may be grown on an extended scale in Sindh. The system of cultivation necessarily limits it to land supplied by perennial canals, but in such tracts the indigenous Sindhi cotton occupies some 100,000 acres, so that there is ample room for its extension. In addition to the substitution of a fine cotton for the worst Indian variety, there is the subsidiary advantage of a considerable saving of water, for the Egyptian cotton requires much less than the indigenous.

There are many points yet to be decided by experimental cultivation. The most important relates to the possible deterioration of staple. It has yet to be seen whether the staple will deteriorate from year to year by continuous cultivation in Sindh, or whether the first year's deterioration is merely temporary, and due to the changed conditions of climate and soil, from which it will soon recover. The apparent normal growth of the plants raises the hope that the latter is the case. Again, further experiment is required to decide which is the best variety of Egyptian cotton for general cultivation in Sindh. As pointed out above, this year's trial points to *Abassi*.

As regards the future, it has been decided to proceed slowly rather than to attempt to secure the sowing of the possible maximum area. At the present stage, the cultivators require to be instructed in the proper methods of cultivation. A leaflet describing these methods has been prepared by Mr. Fletcher, but it is necessary to supervise the cultivation and see that zamindars carry out the instructions, the available staff for which work is limited. For these reasons, it has been decided to aim during the next season at an extension from 1,500 to 6,000 acres of Egyptian cotton. If this succeeds, the extension in future years should be much more rapid. Until the area is large enough to create a market for Egyptian cotton,

special arrangements are required to secure that the cultivators obtain a fair price for their produce. Some commercial firms have been good enough to make such arrangements for the current year's crop, which may be estimated at about 1,000 bales of Egyptian cotton with a value of about Rs. $1\frac{1}{2}$ lakh. It must be remembered that the conditions in Sindh are quite exceptional, as regards very light rainfall, temperature, soil and irrigation facilities, so that no conclusion should be drawn for other parts of India from favourable experiments in Sindh.—(F. G. S.)

* * *

INTERNATIONAL AGRICULTURAL CONFERENCE, ROME.—An important recent event in the history of agriculture is the first International Conference, held at Rome in May last, under the auspices of the King of Italy. No less than forty countries were represented by State delegates. Six were sent by Great Britain, one of whom was Lord Minto, our present Viceroy, so that India is assured of a sympathetic ruler in her efforts towards agricultural improvement. Another was the special representative of India—Sir Edward Buck, K.C.S.I., who was for many years Secretary to the Government of India in the Agricultural Department. The conference decided to recommend the formation of a permanent International Agricultural Institute, in which each adhering State would be represented by the delegates of its choice. This will consist of a General Assembly of all the delegates, which will meet from time to time, executive powers being exercised by a permanent committee of members nominated by the respective Governments. The proposed constitution of the International Agricultural Institute was embodied in an 'Acte Final' which is to be submitted for the consideration of the various Powers with a view to its ratification. The main function of the Institute will be to create an International Intelligence Bureau for the collection, collation and publication of all information of interest to agriculturists. The Institute will thus afford a ready means of obtaining information of the comparative agricultural conditions of all countries. Its publications should be of the greatest value. Special attention will be given to questions relating to agricultural co-operation, insurance and credit. It also proposes to notify all new diseases of plants which may appear in any part of the world, indicating the districts affected, the spread of the disease, and, if possible, the efficacious means of resistance. Measures for the protection of the common interests of agriculturists and for the improvement of their condition will also be taken into consideration. It is evident that an international task of this magnitude will involve a very large annual expenditure. His Majesty the King of Italy has started an Endowment Fund with the magnificent gift of landed property producing an annual

income of £12,000, and each adhering State will pay an annual subscription. If the noble aims of the Institute are fulfilled, an incalculable benefit will accrue to the world's agriculture, of which India will receive her full share.—(F. G. S.)

***

A Root Parasite of Paddy in Malabar (*Striga lutea*, Lour).—A recent complaint has been received as to damage done by "*palli*" or "*the-epullie*" in hill paddy in Malabar. On examination this has been found to be *Striga lutea.* The variety of hill-paddy affected was the local "Modan."

Striga lutea and *S. densiflora* are well-known root parasites on their plants. They usually affect the grass family, and have been recorded as destructive on sugarcane and sorghum in the Madras Presidency. This is the first complaint of their occurrence on paddy. They are small, bright flowered plants, widely distributed over the elevated laterite hills of the west coast of Madras, the home of the hill paddy. The usual remedy for *Striga* is clean cultivation, the stirring of the soil being especially destructive to the delicate roots, which adhere lightly to those of the surrounding plants, and absorb nutriment from them. And as the cultivation of hill paddy is of the most primitive description, their occurrence as a pest is not to be wondered at.

An exactly similar infestation has been described from the West Indies, where *Alectra brasiliensis* was found destructive in badly cultivated sugar-cane lands. Although these parasites need not be feared where anything like intensive cultivation is carried on, yet in those large areas under grain, where little trouble is taken beyond the sowing of a precarious crop, dependent upon casual showers, *Striga*, by reason of its very large number of minute seeds, is liable to great and sudden increase. The land thus planted is not of great value, and it would be well to avoid planting hill paddy or any other graminaceous crop where the ground is studded by these pretty yellow flowers.—(C. A. B.)

***

Composition of Potatoes.—The quality and composition of potatoes is a subject of investigation which is occupying the attention of S. F. Ashby, in the Rothamsted Laboratory, and a preliminary notice of the work has recently appeared in the "Journal of Agricultural Science" (I, 347—357). The points so far dealt with are the high ratio of amide to proteid nitrogen in good tubers; the higher proportion of dry matter in the heel halves than in the basal end; the influence of the physical properties of the soil and the climatic conditions on the quality.—(J. W. L.)

JAVA INDIGO.—The past indigo season in Behar has conclusively proved the superiority of the plant imported from Java (*Indigofera arrecta*) over the variety cultivated hitherto (*I. sumatrana*). Several hundreds of acres of this plant were cultivated and used for manufacture, and the result has been nearly to double the outturn of indigo from the unit area of land. The Java plant is not only more luxurious in its habit of growth than the old variety, but it produces more leaf in proportion to stem and the leaf contains nearly twice the amount of indigo-yielding principle. It is a perennial and can be grown for seed production quite satisfactorily in Behar. A wide extension of the cultivation of this plant is to be anticipated this year, and it is not unreasonable to anticipate that the fortunes of the indigo planters will improve in proportion to this increase.—(C. B.)

*
* *

SOIL INOCULATION FOR LEGUMINOUS CROPS.—Experiments are now in progress in various parts of India to test the application of soil inoculation for leguminous crops along the lines suggested by Dr. Moore of the United States Department of Agriculture. Cultures issued by the latter department have been tried on peas of various kinds and others have been prepared from several native crops and applied to soils bearing them. The results have so far been disappointing. In some cases the crops seem to thrive better in their early stages on inoculated land, but an ultimate increase in crop return has not so far been recorded. It is early yet to draw conclusions, but the results would seem to bear out the theory that Indian soils are normally so well provided with the necessary nodule bacteria, owing to the wide-spread cultivation of leguminous crops, that no beneficial result is to be derived from inoculation. —(C. B.)

*
* *

THE PESTS OF GROUND NUT IN MADRAS.—The district of South Arcot in the Madras Presidency is distinguished by light soils on which the ground nut (*Arachis hypogœa*) is cultivated in enormous quantities. Out of a total area of 440,282 acres in Madras under this crop in 1904-5, 280,984 acres were grown in this district. The staple is, therefore, of commanding importance in the local agriculture.

The pests attacking ground nut are comparatively few, the principal ones being "*Surul*" or "*Mudupuchi*" and "*Tikka*". The latter is a fungoid disease which is not at present very serious in this part of India and apparently prevails in damp, close weather. *Surul* on the other hand is universally present and does great damage. The word "*Surul*" means a "*curling*" and is dependent on the habit of the insect of burrowing inside the tissues of the leaves which curl up and are distorted. The chrysalis is formed in a fold of

the leaf. The insect is a minute dark moth (*Anarampsis nestoria* Meyr.) of very active habits and is probably nocturnal. On walking over the fields a constant shower of disturbed insects flies out, quickly seeking shelter under the neighbouring leaves. The walls of bungalows in the neighbourhood are sometimes blackened at night by millions of the moths attracted by the bright lights.

The *Surul puchi* appears to prefer laying one egg in each leaflet, which speedily turns brown and withers. In a bad attack the whole field assumes a blackened or blasted appearance. As is the case with most pests of this class, showers of rain are most beneficial, while hot sun and dry air lead to rapid increase, whether in dry or irrigated crops.

From the internal working of the caterpillar it is doubtful whether spraying will be of much use, but, on the other hand, it seems probable that light traps may help in destroying the moths at night.—(C. A. B.)

*
* *

COTTON PESTS IN THE WEST INDIES.—A recent number of the "West Indian Bulletin" contains an article by H. A. Ballou on the insects attacking cotton in the West Indies. The cotton worm of the United States is the most serious pest, one that can be checked by the free use of Paris Green. Mr. Ballou states that "the experience of many cotton growers has conclusively demonstrated that prompt treatment with Paris Green in the beginning of an outbreak of cotton worm prevents damage to the plant". Mr. Ballou is to be congratulated upon having secured the co-operation of cotton planters, and this pest is one that apparently need not be feared. "Cotton Stainers" are the equivalent of the Red Cotton Bug (*Dysdercus cingulatus* Fabr.) in India, and the method in use in Pusa is found sucessful also in Barbados. A new pest is the Red Maggot, an insect that feeds under the bark. The Leaf Blister Mite is prevalent, but is checked by the use of sulphur; this pest is probably identical with the leaf blister mite of indigenous cottons in India, which attacks the leaves and is commonly mistaken for a fungoid disease. In India no case has been seen of the plant being damaged, but this might occur if the mite were very prevalent.—(H. M-L.)

*
* *

HYGROSCOPIC CAPACITY OF SOILS—A series of experiments on the hygroscopic capacity of soils carried out by S. Luxmore indicates that the factors which influence this feature primarily are the amount of organic matter, the fineness of the soil and the nature of the mineral matter. Excluding the influence of other factors, the hygroscopicity varies (approximately) inversely as the diam. x its two-thirds power. ("Jour. Agricl. Sci.," I., pp. 304—21).—(J. W. L.)

Mendelism in Sheep.—In a preliminary note published in the "Journal of Agricultural Science," Mr. T. B. Wood gives the results of some very interesting breeding experiments which he has been carrying out for the last three years in Norfolk, for the purpose of testing how far what are known as Mendel's laws for the inheritance of definite characteristics hold good in the case of sheep. For the purpose of the experiment the breeds chosen differed in two definite characteristics, for the ram used was a Dorset ram, with the white face and large horns of that breed, and the ewes were black-faced hornless Suffolk ewes from a herd which, though not pedigree, had been under observation for some years, and were known to be pure as regards these two features. These are the only characters to which at present attention has been paid. The result of the first cross was a number of lambs with speckled faces ; the ram lambs, however, possessed horns while the ewe lambs were hornless. Two of the rams were kept and bred with their half-sisters next year, and it is in the second cross that the results are so particularly interesting, for from this cross were produced pure white-faced lambs, pure black-faced lambs, and lambs with speckled faces resembling their parents ; while as regards their horns, of the eight lambs, five ram lambs and one ewe lamb were horned, while one ram lamb and one ewe lamb respectively were hornless.

It would occupy too much space to enter into a full account of the principles of heredity put forward by the Mendel: but it is enough to say that in cases which conform to his theory, the first cross are all of the same type, whether that of one of the parents, or as in this case, an intermediate type ; while in the second generation, we get splitting into the two original types which were crossed, while others again resemble their parents, that is, they are either like one of the original stock or they are intermediate in appearance. In this case, the photographs illustrating the article clearly show that so far as colour goes the first cross are truly intermediate in type, with speckled faces and legs, while the second cross show lambs which are clearly pure Dorset, others which are pure Suffolk, while others again with speckled faces resemble their parents and are intermediate in type. When we turn to the question of horns in the offspring, we are met with the additional factor of sex. In the lambs of the first cross we find all the males with horns while all the females are hornless ; this is described in Mendelian terms by saying that horns are dominant in the males, recessive in females. The numbers in the second generation are not sufficiently large to give any definite result, but we may note that we find both rams without horns and ewes with horns, showing that splitting is taking place. No doubt the continuance of the experiment will give more decisive results on this point, more

especially as the reciprocal cross, that is the Suffolk ram with Dorset ewes, is being tried at the University Farm. The first generation from this cross, conformably to the Mendelian principles, exactly resembles the first cross-lambs described above.

In view of the extreme interest of this subject to agriculturists who are engaged either wholly or partially in breeding animals, it is to be hoped that experiments on these lines will be continued. The pig might prove a useful animal for this work, since more than one litter may be taken in the course of the year and definite results from the numerical point of view would be more quickly arrived at. ("Jour. Agricl. Sci.," Vol. I., Part 3).—(R. C. W.)

***

SOIL SURVEYS.—A very interesting review of the more recent work which has been undertaken by the U. S. A. Department of Agriculture in the region of soils, is given by Dr. Russell in a recent issue of the "Journal of Agricultural Science" (I., 326—346.) The Bureau has organised a survey of soil types, the basis of which is the mechanical state. An area of some 400 square miles is allotted to one or two experts, who detail its boundaries, give a brief account of its agricultural history, meteorology, geology and the like. Latterly Professor Whitney and his colleagues have directed their attention to the composition of the material in the soil which is soluble in water, and have compared the general fertility of soils with the amount and nature of this material. Two other lines of research include a study of the mode in which water and gases move in the soil. The investigations of alkali land have shown that if the salts are principally chlorides and sulphates ("white alkali") drainage may be effective, whereas if the carbonate predominates, it becomes necessary to destroy it before the land can be reclaimed. The effect of one salt on the solubility of a second has also formed the subject of experiment. The evil effects of excessive quantities of irrigation water are also dealt with. So effective have been some of the methods of treatment that land has risen from a purely nominal value to 250 dollars per acre. In relation to tobacco culture also, new varieties such as the Sumatra, have been introduced into Connecticut, although the climatic conditions necessitated a cover of "cheese" cloth over the whole field.—(J. W. L.)

***

STERILIZATION OF BONE MEAL.—Owing to the risk involved of introducing anthrax in bone meal from India and Australia into New Zealand, the Government of the latter Colony have decided to prohibit the importation of raw bones, and have appointed inspectors to look after the sterilization of bone meal in Australia and India. Regulations have also been laid down to

prevent contact of the raw material with that which has been sterilized either in the mills or during transit. (Annual Report of the New Zealand Department of Agriculture, 1905, page 89.)—(J. W. L.)

*
* *

Testing Cotton Seed.—It is well known that in some cases a considerable percentage of cotton seed fails to germinate after sowing. This failure is generally due to the sucking of the seeds by some of the cotton pests, of which an account was given in the first number of this Journal. The Indian cotton cultivator ordinarily allows for this contingency by sowing a larger quantity of seed than would be required if all the seeds were sound, but better results can be obtained by sowing a smaller quantity of sound seed. A simple method of separating sound from unsound cotton seed has been found in the course of experiments to determine the proportion of seed injured by Red Cotton Bug (*Dysdercus cingulatus* Fabr.). Seed from plants infested with these bugs is often so injured that it does not germinate. The simplest test would be to throw the seed into water, when the bad seed might be expected to float, but the amount of fuzz on ginned seed varies so much that this test is not reliable. If, however, the seed is 'pickled' with cowdung, earth and water, the fuzz does not affect the experiment. The process is to mix equal parts of fine sifted cowdung and earth with sufficient water to make a paste ; this paste is slowly poured over the seeds whilst a man rubs the seeds in the paste. The seeds are then gently separated and dried for two to three hours in a shady place. When dry, they are thrown into water ; the sound seeds sink, the unsound ones float on the surface and are removed. The following figures were obtained in testing seeds : the first column shows the number found bad by this test, the second shows the number found bad by the examination of each seed.

Jullundur	... 88	97
Sialkot	.. 173	190
Umballa	... 181	176
Kasur	... 537	511

In every case 1,000 seeds were treated as above, and a second thousand examined by splitting each seed with a knife. The general agreement of these figures shows that, allowing for the variation between the samples taken, the test is a reliable one. The procedure is simple and the advantage of sowing only sound seed is so great that the extra labour is a small matter.—(H. M-L.)

*
* *

White ants in Sugarcane.—The Report of the Cawnpore Farm for 1904-1905 gives the results of experiments in the treatment, before planting,

of cane sets with various mixtures in order to prevent white ants from eating them. In this connection the following experiments, conducted at the Pusa Research Institute, are of interest. In the first series of experiments, canes were planted in rows and irrigated ; after the lapse of eleven days, the canes were examined and the number then infested noted : they were again irrigated, a small quantity of insecticide being added to the water. They were examined after three days and again after five days. The dates were—planted 7th April, irrigated on 9th, examined 18th, treated 19th, examined 22nd and 27th. This table shows the number attacked after the watering :—

No. of Line.	No. of cane sets planted on 7-IV.	No. of sets attacked on 18-IV.	Treatment on 19-IV.	No. attacked on 22-IV.	No. attacked on 27-IV.
1	45	20	Copper Sulphate.	14	15
2	46	22	,,	15	15
3	54	28	,,	18	27
4	43	23	Crude Oil Emulsion.	2	1
5	38	23	,,	1	2
6	39	26	,,	4	14
7	45	11	Sanitary Fluid.	3	3
8	49	26	,,	1	6
9	43	26	,,	3	8
10	38	18	Rape cake with cane.	6	14
11	34	22	,,	6	11
12	36	24	,,	11	12
13	42	30	Water only.	23	25
14	31	17	,,	13	20

In no case were canes removed, but only taken from the soil, examined and replaced. In the first rows the best results followed from Crude Oil Emulsion ; in rows 10-12, no insecticide was added, but rape cake was buried in the trench when the canes were replaced after the examination. The last two rows were to check the effect of plain water. The amount of Crude Oil Emulsion used was at the rate of thirteen pints per acre, costing approximately Rs. 3. The amount of Sanitary Fluid was the same, at approximately the same cost.

As a check on these experiments half an acre of cane planted in the usual way was treated with Copper Sulphate, Crude Oil Emulsion and Sanitary Fluid ; the cane was untouched and allowed to grow ; as no rape cake was applied, the growth was poor compared with the rest of the field, but the check rows, irrigated with pure water and not manured, were no better, showing that this was not due to the insecticide but to lack of manure. Subsequent manuring brought on this plot equal to the others. This experiment showed that the application of these amounts of insecticide in the irrigation water was not prejudicial to the cane.

A second series of experiments was carried out to test soaking the canes. They were dipped in the following solutions :—

Copper Sulphate, saturated solution in cold water.
Crude Oil Emulsion, one in four of water.
Sanitary Fluid, one in four of water.
Soft Soap Solution, one in four of water.
Gondal Fluid, one in four of water.

The last two rows were planted in ashes, that is, the trench was filled with trash which was burnt, the setts being laid over the ash. The next table gives the results. As before, the canes were planted on the 7th April, examined on the 19th and then dipped, and examined again on the 22nd and 27th.

No. of Line.	No. of canes planted on 7-IV.	No. infested on 19-IV.	Treatment after examination.	No. infested on 22-IV.	No. infested on 27-IV.
15	35	15	Copper Sulphate Solution.	1	2
16	33	11	Do.	2	2
17	29	10	Crude Oil Emulsion.	0 1	1 4
18	34	8	Do.	1	4
19	30	13	Sanitary Fluid.	0	0
20	37	8	Do.	0	0
21	44	13	Soap Solution.	1	0
22	40	18	Do.	3	6
23	37	14	Gondal Fluid.	16	13
24	40	16	Do.	19	11
25	43	22	Ash.	...	27
26	46	37	Do.	...	15

In this case Sanitary Fluid gave the best result. These tests are good, as the ants had already infested the canes and there was no doubt that but for the treatment, a large percentage would have been destroyed. As before, a test was made by dipping cane sets used in the ordinary planting in the same solution ; these canes germinated freely and there were no losses from this cause.

These experiments show that some advantage is gained by dipping canes in solutions, but further practical trials are needed to ascertain the cost of the treatment. It may be noted that Crude Oil Emulsion and Sanitary Fluid are not the same as oil ; they both mix with water freely. This may explain the fact that they do not impair the germinating effect of the cane. The experiments also show that cane planted with rape cake is liable to attack by white ants.—(H. M-L.)

LITERATURE.

The Annual Report of the Department of Agriculture, New Zealand.—The value of co-operation in agriculture is nowhere better exemplified than in the case of New Zealand; and though it may be doubted whether excessive State control really leads to the highest possible efficiency of the individual, there can be little doubt that it has enormously improved the agricultural conditions of this prospering colony. It is in the dairy industry that this control is more especially marked; the State assists in the building and equipping of dairy factories, gives advice as to the feeding of cows, provides bulls for breeding purposes, and supervises the whole process of manufacturing cheese and butter up to the final stage of grading and storing prior to shipment. This grading is a most marked feature in the disposal of agricultural produce in New Zealand; thus wool, meat, poultry, eggs, and New Zealand hemp (*Phormium tenax*) are all graded by State Inspectors and warehoused before export. The enormous saving in packing and transport is further increased by the extra value which these products thereby acquire in foreign markets, and there can be little doubt that the rapid establishment of, *e.g.*, the dairy trade (the value of butter exported has risen from £66,000 in 1895 to £342,000 in 1905), in the face of the competition of Denmark, Russia, and France, has been due mainly to the general adoption of this system.

The record of research work is small: the scientific staff appear to be mainly engaged in work such as milk testing, analysis of samples of feeding stuff and manures, inoculation experiments on plants, identification of specimens and so on. These fill most of the report, while the rest is occupied with short accounts of some of the commoner fungus and insect pests with their remedies. The book is well got up and plentifully illustrated, the latter, especially the half-tone reproductions of photographs of specimens, being of the highest order.—(R. C. W.)

STANDARD WORKS ON ENTOMOLOGY.

[In the following notes, attention is drawn to some standard works on Insect Life, which should form part of the library of an Agricultural College, and with which a student of agricultural entomology should be familiar. The volumes reviewed in this issue are eight in number; others will be noticed in the next issue.]

*
* *

1. INSECTS. BY D. SHARP. *Cambridge Natural History. Vols.* V, VI, *MacMillan & Co.*, 17*s.* each volume.

In these volumes Dr. Sharp has compiled a natural history of insects, embracing their structure, classification, and habits. The amount of information condensed into these volumes is very large, and a perusal of them gives a good general idea of the insect life of the world as now known. The author touches on recent investigations and sums up many of the questions on which authorities still differ. The insects specifically mentioned cannot be numerous, but Dr. Sharp draws his examples from all regions of the globe, with a slight preference for those of Great Britain. Among the few errors in the volume is the doubt the author throws upon the statement made in Indian Museum Notes that the *bherwa* (*Schizodactylus monstinosus* Dr.) of Darbhanga does not burrow. As every one in Behar knows, the *bherwa* is a burrowing insect, but its bizarre appearance and structure led Dr. Sharp into error. The student of insect life will find no better book to read, and a thorough knowledge of these pages would be an excellent introduction to the study of insects. Every library to which students have access and every Agricultural College library should contain Dr. Sharp's work, which is admirable, not only for the learning in it but for the excellent spirit in which it is written, the spirit of the naturalist who studies, not the dead insect only, but the living organism as it can be found in its natural surroundings.—(H. M-L.)

*
* *

2. MANUAL FOR THE STUDY OF INSECTS. BY J. H. COMSTOCK AND A. B. COMSTOCK. *Comstock Publishing Company, Ithaca, New York.* Third Edition, 1899.

A volume of nearly 700 pages with over 800 woodcuts and plates, dealing with entomology as taught in the Cornell University. The volume has been prepared largely with a view to providing teachers and students with a reliable text-book, dealing principally with the classification of insects into families and the habits and life histories of these families. The examples

discussed in detail are wholly insects of the United States and the classification adopted is not that of Sharp in the book reviewed above. There is no difficulty in co-ordinating the two systems, and a student reading Sharp's works will find Comstock a help in the actual discrimination of families. The accounts of the families are excellent and should be read with Sharp's, as giving an idea of the insects of the New World in particular. The volume is valuable principally in the laboratory, where precise methods of classification, keys to families and similar information are required to help in placing each insect in its family. The author has much to say about common pests, and as closely allied insects are injurious all the world over, the student of economic entomology will find much that is valuable.—(H. M-L.)

*
* *

3. THE INSECT BOOK. By L. O. HOWARD. *Doubleday, Page & Co., New York*, 1902. Price $ 3. (Rs. 9).

This volume is the second of a series dealing in a popular manner with all classes of insect life in America. The companion volumes are to be Butterflies, Moths, Beetles, of which the first two have appeared. In this volume, Dr. Howard, the chief of the Division of Entomology in the United States Department of Agriculture, deals with all other insects. As the author says: "*Most books tell what is known, but here we shall try also to point out what is not known but which, nevertheless, can be more or less easily found out.*" We would much like to see such a book written also for India, though it would chiefly deal with what is not known but much of which can be *very easily* found out. The insects are discussed under families and in nearly all cases a typical life history is given as an example. The illustrations are largely colour photographs of the actual pinned insects, and embrace a very large number of species. Little mention is made of economic insects and the book is simply a very readable and accurate natural history of insects, suited to students and those who have some knowledge of classification. The volume should stand with Sharp in every public library in India and, with Comstock also, in every Agricultural College where entomology is taught.—(H. M-L.)

*
* *

4. HANDBOOK OF DESTRUCTIVE INSECTS OF VICTORIA. By C. FRENCH. Parts I to III. 1891-1900. Published by Authority. *R. S. Brain, Melbourne.* Price each, 2*s.* 6*d.*

At a time when economic entomology had scarcely been commenced in India, the Government Entomologist of Victoria was publishing the first part

of this work, dealing simply and thoroughly with the pests of Victoria and the means to be adopted for checking them. The principal part of each volume consists of a detailed description of a variety of pests, illustrated by admirable coloured plates. In all, over fifty pests have been discussed, and there are sections dealing with quarantine, fumigation, spraying and the like ; insectivorous birds are also discussed. Few of the insects mentioned occur in this country, but the life histories are in all cases valuable knowledge, and the methods of treatment, though not suitable to the circumstances of the ryot, are examples of the methods developed in modern agriculture. The volumes illustrate what can be done by a worker almost single-handed in a large country with the co-operation of skilled and keen farmers, and we hope shortly to see a further issue of the author's investigations.—(H. M-L.)

*
* *

5. INSECT LIFE. By C. V. RILEY AND L. O. HOWARD. WASHINGTON, U. S. A. Vols. I-VII. (all published), 1888-1895.

This periodical was for seven years the official publication of the Entomological Division of the United States Department of Agriculture, and was replaced by the Bulletins now issued by the Division. The periodical was devoted mainly to economic entomology and contains a vast mass of information on the insect pests of the United States and, to some extent, of the whole globe. No periodical before or since has maintained so high a standard or dealt so ably with all phases of economic entomology. As a guide to the pests of the United States, and as a general dictionary of matters relating to economic entomology these seven volumes, if a little out-of-date, are still unique. The general index at the end of Volume VII gives ready reference to the whole contents. The articles are extremely readable and interesting, and the student will find accounts of the work of the masters of economic entomology who contributed to these pages. The volumes are hard to get but should be in the libraries of Agricultural Colleges where entomology is taught.—(H. M-L.)

*
* *

6. THE COCKROACH, AN INTRODUCTION TO THE STUDY OF INSECTS. By L. C. MIALL AND A. DENNY. *L. Reeve & Co., London*, 1886.

The cockroach is here selected as a type of insect and the authors discuss its natural history, anatomy, reproduction, development and geological history. The result is a very thorough account of this world-wide insect, and the book is an excellent introduction to the detailed study of individual species of insects in all their phases. For the student it is an excellent model

of what should be aimed at in the study of insects, the detailed study of individual species of insects being a great desideratum at the present time. We commend this little book as a model to all would-be students and investigators, for whom it was originally written, and also to any who have a general knowledge of insect life but are ignorant as to how they may investigate an insect and add to our scanty knowledge of Indian entomology. When entomology is taught in India, we may hope to see its results in the shape of readable monographs on our common insects.—(H. M-L.)

*
* *

7. THE COLOURS OF ANIMALS. BY E. B. POULTON. *Kegan Paul, Trench, Trubner & Co., Ltd.* Second Edition, London, 1890. Price 5*s*.

In this volume Professor Poulton discusses the meaning and use of colour in animals, a subject he has made peculiarly his own and on which he is the foremost living authority. Though written in 1889, the book is still a standard one. The meaning and use of colour has engaged the attention of naturalists from the time of Darwin onwards. It was Wallace who suggested "warning colouration" as an explanation of the curiously vivid colouration of a caterpillar found by Bates in South America; it was Bates himself who found the form of mimicry named after himself, and since then Mullerian mimicry has been applied to the common possession by large numbers of insects of a simple scheme of warning colour. Since then Poulton has made great advances; he has shown how these hypothetical explanations are actual facts and has demonstrated that these schemes of colour are a vital factor in the daily lives of insects, and not an adaptation worked out ages ago and still maintained unchanged through the laws of heredity. The volume is one to be read and then thought over in the field. The colouring of most insects has still no meaning for us, but it is not hard to find many insects whose colouring is evidently cryptic or warning, offensive or defensive. Perhaps in tropical India this is easier than elsewhere, and the student of Indian insect life will find many applications of the principles laid down by Professor Poulton in these pages.—(H. M-L.)

*
* *

8. THE NATURAL HISTORY OF AQUATIC INSECTS. BY L. C. MIALL. *Macmillan & Co., London*, 1903.

A little volume devoted to the habits and customs of the insect world that lives in ponds and streams, written by a master in the study of the living organism, with a view to interesting students in nature. There is no more fascinating branch of entomology than the study of those organisms which live in water, who have adapted themselves to totally new surroundings

and who exhibit such a wealth of devices whereby to secure the necessary modicum of air for daily life. The water beetle, the whirligig, the water tiger, the boatman, the pondskater, the caddis worm, these and innumerable other fascinating "beasts" live again in these pages and renew the thrills with which one watched them in the streams and ponds of our youth. Many of these insects can be found in this country, and we should commend them to the student anxious to probe the mysteries of nature; a net of coarse cloth, a pocket lens, a few shallow open pots and this little volume form the sole outfit required with which to investigate the fauna of any tank or stream. Any one with a love of nature will find abundant delight in watching the "beasts" when they have come up from the muddy depths, and Professor Miall is an admirable guide in these delightful excursions into nature.—(H. M-L.)

***

LOCUSTS IN USAMBARA. BY PROFESSOR DR. VOSSELER. *Berichte uber Land und Forstwirtschaft in Deutsch-Ostafrika.* Vol. II, No. 6.

In this report, Dr. Vosseler gives an account of his observations on the familiar locust of Northern India (*Acridium peregrinum* Ol.). A large amount of literature about this locust already exists, but Dr. Vosseler's account is of great interest, and though not in any way exhaustive, throws new light upon some obscure points in the life of this insect. The locust's habits in German East Africa are in general similar to what has been observed in India. The peculiar change of colour from purple red to yellow is stated by Dr. Vosseler to be entirely associated with the development of the reproductive system; the yellow colour is an indication that the ovaries are ripe and that egg-laying will shortly take place. The periods of the life history are: eggs, 16 to 18 days; development of hoppers, 50 days; sexual development of locusts, 16 to 20 days. About three months are required from the date of egg-laying to the time the insect is ready to lay eggs. The hopper passes through five stages, having five moults to undergo. In discussing measures of protection and destruction, Dr. Vosseler concludes that the hoppers in the first two stages are most easily destroyed and that this is the time when the most valuable work can be done. He was unable to test the destruction of egg masses, as none were found in very large quantities. The method adopted of destroying hoppers in the first two stages (*i.e.*, within twelve days of hatching) was watering or spraying with a three per cent solution of hard soap. This is a somewhat surprising method and it will be worth testing it in India when the opportunity arises. Dr. Vosseler also recommends the method universally adopted of driving the hoppers into ditches behind which are placed screens. His method does not differ from that adopted in Quetta.

Against the flying locusts no methods were of avail; the Natal arsenic solution was tested but was destroyed in heavy rain. The fungus used in the Cape was tested, but in the opinion of Dr. Vosseler is too slow to be practical. No method is recommended for destroying flying locusts, and the only precaution is to make noises or to worry the locusts so that they do not settle but fly on. The report is well illustrated and contains much that is new and of interest.—(H. M-L.)

***

NOTE ON IRRIGATION BY PUMPING FROM A WELL AT MELROSAPURAM. BY ALFRED CHATTERTON. (*Bull. No. 54, Department of Agriculture, Madras.*)

In this *Bulletin* Mr. Chatterton gives the details of the amount of water raised from a well near Chingleput (Madras) by means of a centrifugal pump driven by an oil-engine. The subject is of much economic interest, because it is certain that if mechanical power can be applied to wells in India, the advantage over present methods will be very great. This account refers to the operations during 1903 to 1905 and shows the quantity of water raised per hour, the rate at which water percolates into the well, the cost per hour while pumping and the area irrigated. All persons interested in raising water from wells should study the figures given in this *Bulletin*.—(J. W. L.)

***

THE BOOK OF THE ROTHAMSTED EXPERIMENTS. BY A. D. HALL, M.A., *Director of the Rothamsted Experimental Station, First Principal of the South Eastern Agricultural College.* Published by John Murray.

We have just received a copy of Mr. Hall's latest production, and a glance at it reveals a book excellent in type and profusely illustrated. It opens with the biographical sketches of Lawes and Gilbert which Mr. Warington wrote for the Royal Society, and a perusal of these alone is a certain stimulus to any one deeply interested in Agriculture to try and follow in a similar path. The remainder of the book is, as the title sufficiently indicates, a résumé of the results of the various experimental researches which were conducted at Rothamsted during the fifty-seven years that Lawes and Gilbert worked together. Taking one of these principal researches as the subject of each chapter, Mr. Hall shows the reader the nature of the experiment, its objects and its lessons. Each chapter closes with a list of the Rothamsted literature dealing with the subject. One may thus travel through those interesting avenues, which lead us to a knowledge of the sources of the nitrogen of our crops; how different classes of fertilisers affect the cereal, the legume or the root crop; the value of rotations; the effect of foods

on the animal, and the value of the farm manure obtained. The several chapters thus form a connected whole, and yet are so self-contained as to enable the reader to comprehend from each of them the subject with which it specially deals.

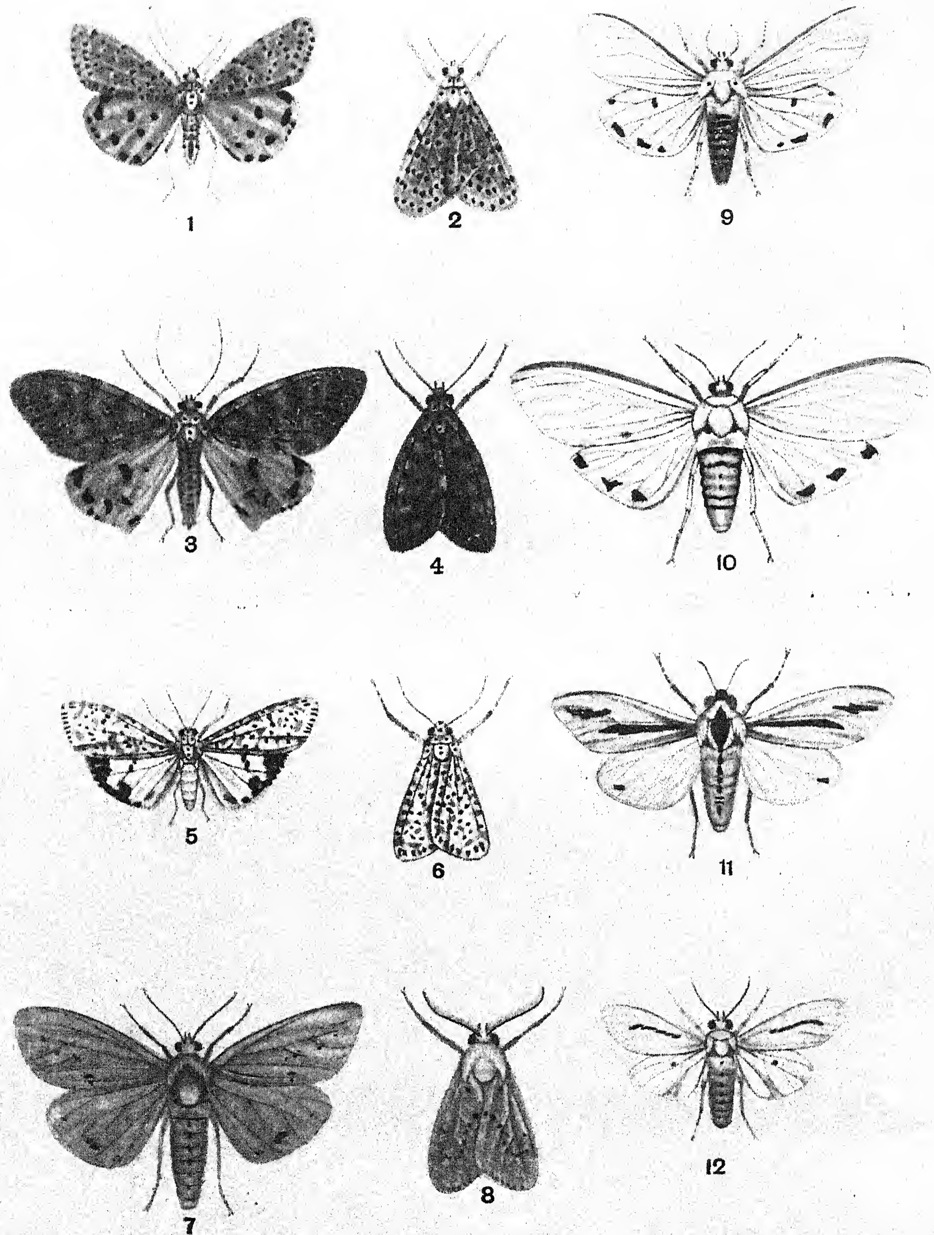
Mr. Hall tells us in the preface that he has written the book for three classes of readers, namely, the landowner or farmer, the agricultural student, and the teacher and expert. There can be no doubt that in Europe and America the book will be highly appreciated by all these several groups of persons. To those agriculturists in India who read English we may also confidently recommend it; the style is excellent for the end in view, the type is large, and the illustrations, diagrams and statements of results leave little to be desired.—(J. W. L.)

***

INDUSTRIAL CONFERENCE, BENARES.—A collection of the papers read at the recent Industrial Conference at Benares has been published in book form by Natesan & Company, Madras. As might be expected the papers are of very varying merit, but amidst much chaff there is some good grain. The large proportion of the papers devoted to agriculture is evidence of the enlightened spirit which is now being awakened in the development of India's greatest industry. They will well repay careful study. It is interesting to note what a very large number of the authors reach the same general conclusion—that the greatest problem of agricultural improvement is the provision of capital for the financing of the cultivators. The remedies suggested for the existing want of capital are many and varied. One suggests that Government should as an experiment clear off all cultivators' debts in a selected tract; another proposes bankruptcy proceedings on the model of the 'conciliation' methods of the Central Provinces; a third alternative is a joint stock bank with a Government guarantee and other privileges; whilst the majority believe that salvation lies in co-operative credit. The latter movement seems undoubtedly to be making headway in several parts of India. The forms which Co-operative Credit Societies are taking in several provinces differ considerably, as might be expected with the great differences in local conditions. They vary from the small caste bank of a United Provinces village to the more ambitious efforts of Madras banks with a substantial capital, largely subscribed by the local moneylender. Agricultural Associations also appear to be exciting a considerable amount of thought. An interesting account is given of the organization in the Madras Presidency. Whilst admiring the intense enthusiasm and large amount of energy shown by the Central and District Associations of this province, we would suggest a somewhat more cautious advance. It would seem that associations are starting

a good deal of work of a purely experimental nature, much of which is almost bound to fail owing to want of proper equipment for carrying it through efficiently. New methods of cultivation, new crops and new implements should hardly be recommended until there is a strong probability of their suitability to the district. Whilst it may be possible to carry out simple experiments on a co-operative system by the agency of Associations, the safe broad line of distinction might be more clearly adhered to, under which experimental work is the province of the Department of Agriculture, and demonstration work for the introduction of proved results the natural sphere of operations of the Associations. The appeal to the zamindars of Bengal to devote their energies to the cultivation of cotton is one which we hope will fall upon deaf ears. In the past century there have been many experiments devoted to the improvement of cotton in Bengal, all of which have ended in failure. All past work tends to disprove the statement that the soil and climate are favourable to the cultivation of fine staple cotton. Recent trials by the Department of Agriculture point to the same conclusion. The superiority of Bombay cotton is certainly not alone due to superior methods of cultivation, and we believe that climatic conditions will always prevent Bengal from competing with her Western sister in cotton cultivation.—(F. G. S.)

PLATE XV.



MOTHS OF HAIRY CATERPILLARS.

HAIRY CATERPILLAR PESTS OF CROPS.

By H. MAXWELL-LEFROY, M.A., F.Z.S., F.E.S.,

Imperial Entomologist, Agricultural Research Institute, Pusa.

Amongst the many injurious insects in India, one small group may clearly be distinguished both in appearance, habits and destructive effects upon crops. These insects are familiar to cultivators in their immature but destructive stage when, as hairy caterpillars, they appear in vast swarms and ravage whatever green crops may be on the ground. These swarms of caterpillars are a very distinct feature in some tracts, appearing at definite seasons, lasting for short periods only, and re-appearing after some weeks' interval. So much the cultivator sees and knows, but this caterpillar stage is the only one of the insect's life familiar to him. When the caterpillars have eaten their fill of the crops, they disappear naturally, but unfortunately they are not, as would appear, dead or devoured by birds. They re-appear in their final stage of life as moths. In this stage they are not generally familiar, certainly not to the cultivator and perhaps only to the few who may happen to know something of the natural history of the insect. Yet as moths, they are very easily and distinctly recognisable, and their appearance in the field or at a lamp by night is a valuable indication of the probable occurrence of the pest in its destructive form during the following few weeks.

The life of the insect from stage to stage is best illustrated by the entries on the cage slip of the Pusa Insectary referring to the "Orange Sann Moth" (Plate XV, Figs. 1 and 2). The entry is as follows :—

4th August : Eggs laid by moth on the leaves of sann hemp (*Crotalaria juncea*), in a breeding cage.

8th August :	Eggs hatched.				
	Caterpillar	2	mm.	($\frac{1}{12}$ in.)	long.
17th "	"	7	mm.	($\frac{2}{7}$ in.)	long.
21st "	"	16	mm.	($\frac{2}{3}$ in.)	long.
24th "	"	25	mm.	(1 in.)	long.
25th "	Pupation commenced.				
31st "	Moths emerged.				

6th September :	Moths laid eggs.
8th ,,	Eggs hatched.
19th ,,	Caterpillars full grown.
21st ,,	Pupation commenced.
28th ,,	Moths emerged.

Here we have two complete life cycles in less than two months. At two periods, about August 21st and September 17th, the cultivator would see caterpillars eating his crop, and again at two other periods, August 4th—8th and September 1st—6th, he would perhaps see moths; if he connected the two occurrences, he would, on seeing the moths, anticipate the next brood of caterpillars and be ready to destroy them.

It is this aspect of prevention that I wish to bring forward, the recognition of some of our commoner insects in the perfect condition, that is, as moths when they are about to lay eggs. This group (hairy caterpillars) is the best example of the value of recognising the perfect insect as an indication of approaching pests, because the moths are extremely characteristic in appearance and are found either flying in the fields by day or round lights at night.

An instance also of the value of this means of anticipating pests may be given in the method adopted of checking the Behar hairy caterpillar. During 1904, this caterpillar ravaged certain crops on the Pusa Experimental Farm which was then being brought into cultivation ; appearing in great numbers, they devoured certain favourite crops and at several periods were a serious menace to part of the cultivation. All that could be done at that time was to rear the caterpillars to moths and determine their identity. In the following year the first moths were seen in March ; a search for them was made in the crops, and their eggs were first found and destroyed about the 20th of that month. They re-appeared in May, were again searched for on crops and many eggs found and destroyed. The next brood was expected on June the 22nd but did not appear ; no caterpillars were found, and the absence of the brood was attributed to the unusual lateness of the rains. The rains finally broke about July the 22nd, when moths were again seen ; their eggs were collected in the fields from July the 26th to August the 1st. Another and final brood was seen on September the 11th, and a small number of eggs was discovered and destroyed. Throughout the season nothing else was done. When the moths were seen at lights or sitting on walls, a watch was kept for eggs laid in the fields, and when these were discovered, both the eggs and young caterpillars were destroyed. A common labiate weed, as well as the sann hemp, til (sesamum), sunflower and groundnut crops, were examined for eggs. At a very small cost

for labour and supervision, the farm was kept clear of an injurious pest that would otherwise have done great harm, or necessitated laborious spraying operations.

This case was an exceptionally valuable one, as the broods re-appeared several times and the value of the method was conclusively shown. In other species there are fewer broods, and an outbreak may be anticipated only twice during the rains. There is also the further consideration that, if the first batches of eggs are secured, the pest has not time to breed several times in succession, and become very numerous during that year.

In almost all cases of large caterpillar outbreaks, the fact that the moths are seen beforehand is a valuable indication, but it is naturally impossible for the untrained mind to recognise more than a few very characteristic insects. It is for this reason that I figure the moths of these hairy caterpillars, which are most characteristic, which usually attack definite crops, and which appear near lights or in the fields at fairly regular seasons. The essential and vital fact is to foresee the attack of caterpillars, if possible, and to destroy the eggs or young caterpillars before the latter are large enough to wander. For this reason the recognition of the moths of these caterpillars is of great importance, for there is no other easy method by which such swarms can be successfully checked. The moths of the common species are figured in Plate XV, and the representations give so accurate an idea of the insects that there should be little difficulty in identifying them.

The "Orange Sann Moth" * (Figs. 1 and 2) lays its eggs on sann hemp and wild *Crotalaria*. It is common in the plains, widely scattered, and attacks this crop during the rains. Depending on the supply of food, there may be five broods in the year, but there are usually about three. The moth is likely to be seen at any time in the rains; it is not attracted to lights, but is very easily discovered in the fields, as it flutters about among the sann hemp plants. The eggs and young caterpillars are found in clusters on the leaves and should be picked off and burnt.

The "Crimson Sann Moth"† (Figs. 3 and 4) is a rarer insect, but behaves similarly to the Orange species and has been found to be equally destructive when abundant. The "Red Spotted Ermine Moth"‡ (Figs. 5 and 6) is another very distinct species common in the plains, also attacking sann hemp. It flutters about in the daytime and the moths are readily seen and recognised. Like the Orange Sann Moth, its eggs or caterpillars should be looked for when the moths are seen in the fields. The "Diacrisia

---

* *Argina cribraria.* Cl. † *Argina syringa.* Cram.

‡ *Utetheisa pulchella.* Linn.

Moth"* (Figs. 7 and 8) is common in Behar, Oudh and in some localities near the hills, and is possibly a hill species that spreads into the neighbouring plains. It is very abundant in Behar, attacking sunflower and leguminous plants, and also ravaging cotton and various crops if other food fails. The moth is attracted to lights or may be seen sitting on walls, and in favourable years there may be as many as six broods in the year.

The "Red-banded Amsacta"† (Fig. 9) is found widely but less abundantly distributed over India. It appears to be very abundant only at long intervals, and specially attacks groundnut crops. The moth is like the following one but is distinguished from it by its red abdomen. The "Orange-banded Amsacta"‡ (Fig. 10) is a larger insect, also attracted by lights, or, if disturbed, found flying in the fields. It has a wide distribution and attacks sweet potato, sunflower, rice, sesamum and sorghum. Its development is slower, and there is a smaller number of broods in the year. Like others it may be looked for first in the early rains, but as it eats wild food-plants, it may not be found in the crops unless exceptionally abundant.

A commoner insect is the "Black-streaked Creatonotus"§ (Fig. 11), a moth which is easily recognised by the interrupted black streak in the fore-wing, which is not so white as in others. The moth comes to lights and may be seen in abundance. So far as is at present known, it is the only common moth of this kind which is harmless, and if seen, no outbreak of caterpillars on crops need be expected. It will probably be found to attack crops in time of stress, but is not one of the major important insect pests. Finally there is the little "Black-lined Amsacta",|| a smaller insect with pinkish fore-wing having a narrow, black line. With the orange-banded species, this appears in the rains; its caterpillar is familiar in Baroda and Gujarat as "*Katra*" and occurs generally over India. This is one of the many caterpillars that attack indigo, and in a bad year many other crops suffer from its ravages.

The above eight insects comprise the known injurious species and, though others will be found, these are the only ones of general importance in India. We may add that the term "hairy caterpillar" is meant to apply only to caterpillars eating crops. It does not here include the hairy caterpillars (*e.g.*, the "*Kumbli-Poochi*" of Mysore) found on trees nor the many hairy caterpillars found in jungle or forest land.

* *Diacrisia obliqua*. Wlk.
† *Amsacta moorei*. Butl.
‡ *Amsacta lactinea*. Cram.
§ *Creatonotus gangis*. Linn.
|| *Amsacta lineola*. Cram.

These moths lay eggs in the same characteristic manner, depositing as many as fifty, sixty or even a hundred, in a cluster on the underside of the leaf of the food-plant ; such clusters are irregular, and look as if a pinch of poppy seed had been put on the leaf and then stuck to it, with a sprinkling over it of short hairs. The moth lays several such clusters ; a female orange-banded Amsacta laid nearly six hundred eggs in the insectary, 530 young being counted when these eggs hatched. The egg clusters are on the lower side of the leaf as a rule ; it is not difficult to find them if one walks through the field when moths are seen ; and if all are not seen, the caterpillars are easily obtained when they hatch.

The little caterpillars hatch out together and feed first on the leaf they are on and those close by. One then sees a plant of which some leaves are eaten or spotted, the caterpillars either eating the leaf entire or nibbling the epidermis on both sides, giving the leaves a peculiar spotted appearance. A day or two later, the caterpillars have spread a little, and one sees a group of plants of which the leaves are totally destroyed, the little caterpillars then beginning to spread. They are still gregarious enough to be found in groups on the leaves, and it is then only necessary to pluck and destroy the leaves on which there are caterpillars. A basket or kerosene tin is required in which to collect the leaves, the leaves being burnt, or buried in the soil, or simply shaken over a vessel containing water on which a little kerosene is poured, when the caterpillars fall in and are killed. The vital factor in checking these pests is to recognise the moths, and when these are seen, to watch in the field for eggs or for the young caterpillars. The latter are found a few days after the moths are seen and are the most easy to detect, but when moths are actually seen in the crops, there is usually little difficulty in finding the eggs there.

Explanation of Plate.

Fig. 1. Orange Sann Moth as seen flying in the field.
Fig. 2. ,, ,, ,, as seen resting on a plant.
Fig. 3. Crimson Sann Moth as seen flying.
Fig. 4. ,, ,, ,, as seen resting.
Fig. 5. Red-spotted Ermine Moth as seen flying.
Fig. 6. ,, ,, ,, ,, as seen resting.
Fig. 7. Diacrisia Moth as seen flying.
Fig. 8. ,, ,, as seen resting.
Fig. 9. Red-banded Amsacta as seen flying.
Fig. 10. Orange-banded Amsacta as seen flying.
Fig. 11. Black-streaked Creatonotus as seen flying.
Fig. 12. Black-lined Amsacta as seen flying.

FLAX EXPERIMENTS IN INDIA.

By BERNARD COVENTRY,

Director, Agricultural Research Institute, Pusa.

CAN flax be grown and manufactured in India? This is a question which has exercised the minds of individuals and of the Government of India for over a hundred years, which is still being asked to-day, and still remains unanswered. India produces 300,000 tons of linseed per annum valued at about 3 millions sterling. The plants from which this seed is derived are either thrown away or used as fuel. It is only natural that this country should have been looked to as a source of supply by those interested in the production of flax, and the saving of the fibre from destruction has been a cause of keen speculation to many.

The earliest attempts to produce flax in India appear to have been made at the beginning of last century by Roxburgh, in a Hemp Farm established by the East India Company in the neighbourhood of Calcutta. His experiments were confined to the Indian linseed plant, and though samples were prepared and sent to England, no definite conclusions are recorded as to whether the trials were a success or not.

In the year, 1839 the matter was taken up more seriously, and a Company was formed, having as its object the growth of flax in India. Riga and Dutch seed was imported. as it was thought probable that the Indian plant, which had for centuries been grown for the production of seed only, was not as good for flax production as the Russian and Dutch varieties, grown in those countries principally for fibre. The subject was warmly taken up, and extensive experiments were carried out, principally in Bengal. Samples of fibre were valued in England at £30 to £45 per ton, and a very favourable view was taken of the probabilities of a profitable enterprise. The Agricultural Society of India, as the result of a request from Government in 1841, submitted a report of these results, and we find the Revenue Secretary to the Indian Government writing to them on the

22nd November 1841, that, "the cultivation of flax can no longer be considered a doubtful experiment, since it appears from your report to have been found in many instances successful, and where successful, to be very fairly profitable. His Lordship in Council is, therefore, much inclined to doubt whether any bounty or reward from Government is necessary or would be justifiable." Notwithstanding these favourable results, the Company did not continue the experiments, and the inference to be drawn is that the refusal of the aid, for which they applied to Government, forbade their risking any more in the venture. Indeed we find Mr. Wallace, who conducted trials for three years, stating in 1841 that the speculation must be abandoned unless the Government gave some encouragement.

In 1856 and following years, the subject was again revived, and we find experiments started in the Punjab, N.-W. P. and other parts of India with both indigenous and imported Dutch and Riga seed. In a letter addressed by the Personal Assistant of the Financial Commissioner to the Government of the Punjab, dated the 20th July, 1859, the results of the experiments in the Punjab are stated. The price realised in England for the fibre varied from £35 to £45 per ton, and the results are described as being "most encouraging and gratifying." "It has now been experimentally proved that flax grown from country seed in the Punjab can command a first class price in the European markets, leaving a large margin to cover cost of transport, &c., and for profit. The question may, therefore, be said to have passed from the stage of speculation and surmise to that of fact."

Reports of Dr. Jameson, Superintendent of the Saharanpur Botanical Gardens, written in the year 1859, give the following information. The height of the plant was $3\frac{1}{2}$ to $4\frac{1}{2}$ feet. The yield of seed per acre was 7 maunds, and the yield of fibre per acre was 4 maunds. The proportion of fibre to straw was 25%. He says in the reports referred to, "I found that flax might not only be made an excellent paying crop from the seeds alone, but that the stem or shove, if properly scutched, would be admirably fitted for the Home market, but before this can be brought about, it would be absolutely necessary to import good Instructors from Europe."

A Committee composed of members of the Agricultural Society of India was appointed for the purpose of investigating the question of "the cultivation and manufacture of flax in India." After reviewing the past and present history of the subject, they stated that the work in order, "to afford any hope of success . . . . must in the first instance be carried on under European supervision, as the raising of the plant for fibre is unknown to the natives, and the manipulation requires much nicety and judgment." They indicated what aids they considered were necessary, and recommended the "engagement

for one, two, or three years, of persons who are well acquainted with the mode of cultivating and preparing flax after the most recent improved methods." On the 8th March 1860, we find the Secretary to the Government of the N. W. P. addressing the Secretary to the Government of India, to the following effect: "It appears that not only can an excellent paying crop be obtained from the seeds alone, but that the fibre prepared under proper management would be admirably fitted for the home market. This is found to be the case not only by the results of Dr. Jameson's experiment, but also by the results of those conducted on a larger scale in the Punjab—the flax which was there produced having been declared by competent home authorities to be even superior to the Russian flax." The letter goes on to say that "instruction from Europe is indispensably necessary before native cultivators will be able to carry out the somewhat difficult processes described by Dr. Jameson," and suggests "for the consideration of His Excellency the Viceroy that . . . . measures be authorised for the engagement of a couple of competent European Instructors, and the importation of the necessary machinery and seed." To this, the Government of India replied in a letter, dated the 3rd October 1860, that "the experience of success gained in the Punjab should ...... be sufficient to stimulate private enterprise to seek a field for its operations," and that as the practicability of cultivating flax for the English market at a good profit had been clearly established in the Punjab, which could now be left to its own progress unaided, it did not appear that the assistance of instructors was required in the N.-W. P. The Government, however, offered assistance in various other ways, such as the dissemination of literature on flax, aid in the importation of seed and machinery by passing it duty free, rewards and prizes for the production of the best flax, and the loan of the services of Belfast men from European regiments who were acquainted with the art of flax manufacture. These offers were evidently not considered to afford sufficient help, and the subject lapsed once more into oblivion.

I have been careful to quote at some length from the reports and correspondence on past trials, because it is generally assumed in the present day that, experiments having been so repeatedly made and no practical results having emanated from them, the growth and manufacture of flax in India has never been and is never likely to be a success. The object of this article is to show on the contrary that there is no warrant for such a conclusion and that past efforts so far as they went pointed to success. In other words it would appear most probable that flax can be properly grown and manufactured in India, and that if the Government in 1860 had provided European Instructors and aided the birth of the undertaking one step further than

they did, the country would in all probability have possessed an industry at the present day not in any way inferior to that of Jute.

I propose now to consider the experiments which are at present being conducted in Behar. The decline of the Indigo industry, owing to the appearance in 1897 of the synthetic dye, has stimulated the planting community in Behar to seek new fields for their enterprise and capital. Among the new endeavours is the culture of flax. At present only two places have taken the matter up, namely, the Dooriah Indigo Concern in the district of Muzufferpore, of which Sir Lewis Hay, Bart., and others are proprietors, and the Rajpur Indigo Concern in the district of Chumparan owned by Mr. E. Hamilton Hudson and others. The Rajpur Concern has only recently sown down a limited area, the results from which have not yet been ascertained, so that the only useful information at hand is that obtained from the working of the experiments in the Dooriah Concern. The writer paid a visit to this concern in May last and collected what information was then available, and has since received from the Manager, Mr. J. Cameron, further particulars up to date.

The Dooriah Concern has been experimenting in flax for the past four years. Over 100 acres are under cultivation, and they have erected scutching machinery, which turns out 250 lbs. of prepared fibre per day. With skilled workmen it would probably turn out three times that amount. The cost of machinery is comparatively small, that required for all the processes of 'breaking' 'scutching' and the like being about Rs. 2,000. The process of manufacture is as follows:—The plant is cut down when nearly ripe and "rippled" for seed. The stalks are then either retted green, or dried and stacked, and afterwards retted at leisure. The Russian and Irish methods of retting are considered unsuitable for India. Of other methods, the retting of the dried straw as practised in the River Lys in Belgium, where the finest flax has been produced for years, is considered the best, as it facilitates the work by extending it over a longer portion of the year when other work is slack. This process is worked by packing the dried stalks in crates lined with cloth, so as to secure filtration of the water, and then retting at least twice in running water. Great care and judgment is required to regulate the retting in order to secure the highest percentage of clean, long fibre. The vats, available at every indigo factory, can also be utilized to work the improved process known as the "Beerghem" retting system, which has great advantages over other methods. Under this system, in which the dried stalks can also be worked, the retting process is completely under control in a series of vats in which the conditions can be regulated, thereby ensuring uniformity of production. The following

detailed description by an indigo planter of this process is of general interest :—

"I have begun my holiday well, as you will I think agree with me, when I tell you that I have spent yesterday in studying a new process of flax retting which seems to me to offer great advantages and is likely to be a success. It is the outcome of the ideas of a practical mechanic, a Mr. Legrand of (Lille) Antwerp, and a man whose name I could not catch, but whose family from father to son have been for generations engaged in steeping and retting flax in the River Lys, and who has, I understand, been also employed in flax spinning.

"I was allowed to see the whole installation in consequence of my connection with Indian flax-growing, as the patentees came to the conclusion that this process might be very advantageous for India, their idea being that their process will be set up in districts where flax suitable for fibre purposes can be grown.

"Their contention is that they can produce fibre quite equal to the Courtrai steeped in the Lys *and at much less cost*, the Lys process being very costly from the amount of handling, etc., and liable to be interrupted from the state of the river (for instance no flax is at present being treated in the Lys, which is too much in flood) and now and again flax in process is destroyed.

"By this new process, steeping and retting goes on all the year round and the amount of labour required is trifling, but that labour must be intelligent.

"The installation is at a small village called Beerghem about ten minutes by rail from Bruges, or say, half an hour from Ostend. It was started in November last year and up to now 400--500,000 kilos of flax straw have been treated, say 4—500 tons. The installation is set up on the side of a small stream, a mere 'burn' over which you could stride or certainly jump, of sluggish running, not over-clean looking water, probably yesterday with a depth of a foot to a foot and a half, but falling in summer to an inch or two. (I give these details to show that no great volume of water is necessary in this process.)

"The installation consists of a range of light brick buildings, the central feature of which is a long hall containing or rather consisting of a long tank divided into five sections and with a factory along the side. Over these tanks is a sort of travelling crane. In No. 1 tank, next the door, the process begins. The tank is filled with water which has been taken from the 'burn,' and first of all passed through a filtering pit from which it is pumped into the tanks by a system of connecting pipes, by an engine which supplies the power for the whole installation. The water in No. 1 tank is heated to a temperature of 30—31 degrees centigrade (86—88 degrees Fahrenheit) and into this water which is pure and *has no chemicals whatever*, the flax, which is put up in small sheaves and placed in crates standing on its end, is placed or plunged until it is quite submerged and is kept down by a very simple arrangement. Each tank holds three of these crates of flax and the crates are lifted from the trolley by the travelling crane and dropped into the tanks. In the first tank, the flax remains for one day, during which, however, it is lifted in the crate by the travelling crane and held over the tank a few minutes to allow the water to drip through the sheaves, two or three times in the day and then replunged into the tank so that the water rises right through the sheaves, so that you may say every straw gets the full benefit and the steeping is pretty even all through the crate of flax. You see the gums rising in a scum to the surface of the tank and the

stench is horrible. After a day in No. 1 tank, the crates are lifted into No. 2, and remain there, with these occasional liftings, until the retting process is completed. This takes from $2\frac{1}{2}$ days with poor straw up to $3\frac{1}{2}$ to 4 days *outside* for heavy good straw. The process has to be watched *narrowly*, in fact day and night, and the flax lifted from the steep just at the right time, when the process of retting is complete; but two men are all that are necessary to handle the flax from the tanks. Taken from the tanks, the crates are put on trolleys and stand for a day or a couple of days to *harden*, after which the trolleys are run out on a light line of rails to a meadow, where the flax is taken out of the crates, the bundles opened, and the flax is set up in big handfuls on end, three or four of the handfuls being twisted together at the crop end to make them stand, and here it is left to dry and further harden for such a time as is considered necessary, depending very much on the character of the straw, and lasting 3 to 7 days, after which it is ready to be broken and scutched.

"To break it, it is passed through quite a small machine with fluted rollers and then it is worked on the usual scutching mill.

"The yield got from the straw varies from 15—16 per cent. for poor straw, up to 19—23 per cent. for good straw. One object of leaving it on the meadow so long is to give colour.

"The water in the tanks has not to be changed with each fresh crate of flax put into it, but can be used repeatedly until it becomes too dirty and likely to affect the colour of the flax. The water is heated by steam pipes in the tanks I understand. When the water is discharged from the tanks, it flows into a pit next to the filtering pond, through which pit the pipes conveying the fresh water are led, so that by the time the fresh water reaches the steeping tanks its temperature has risen considerably, and there is less steam wasted in bringing it up to 30—31° Centigrade.

"I forgot to mention that the seed has been taken off the flax before it was put into the steep; this is done by a machine which these people have brought out, which does not destroy the fibre. I send you small samples of straw retted by the process and of the flax produced and also of dressed lint and tow, produced by a new system of hackling which Legrand has also patented, but which I won't attempt to describe to you, but by it he claims to get 12—20 per cent. more yield and to produce much better tows than by the old system of machine hackling.

* * * * * * * *

"I believe, it is the very thing for Behar, and as the indigo planters have already their indigo vats, I daresay these could be utilised for the steeping tanks without any great expenditure of money. The installation at Beerghem has cost about £2,400, but a good deal has been wasted, as it was entirely experimental, which would be saved in putting down a new place now after experience has been gained."

As regards the cultivation of the plant, there is no doubt that some of the lands in Behar are admirably suited to the growth of flax. In well-selected land a crop grown from imported seed attains an average height of 3 feet. The amount of seed sown per acre is 2 maunds (160 lbs.), but it is considered better by some to sow two and a half maunds (200 lbs.). Sowing thickly on strong land is said to produce a higher percentage of fibre,

for a number of thin stems having the weight of one thick one will have a greater surface and consequently more fibre. The land requires careful preparation. It should be ploughed to a depth of ten to twelve inches, and then carefully worked so as to secure a firm seed bed and a fine surface. Careful broadcast sowing by hand produces a more uniform thick crop than sowing in drills. Some of the best foreign varieties of seed are under trial at the Pusa Experimental Station. It has yet to be ascertained whether the seed will maintain its quality with acclimatization or whether it will be necessary to import fresh seed at regular intervals. It is well known that linseed cannot be grown continuously on the same land, which becomes "flax-sick." In Belgium, the rotation is as long as a five or seven years' course.

If grown in this way, experience shows that there is as much fibre in the plant grown in India as at home, namely, about 20 per cent. of dried straw. The average yield of retted and dried straw at Dooriah from sowing at the rate of 2 maunds of seed, was 40 maunds per acre, and the percentage of fibre obtained from the straw was 15 per cent. or 6 maunds of fibre per acre. This should have given $4\frac{1}{2}$ maunds good fibre and $1\frac{1}{2}$ maund of tow, that is to say the proportion of good fibre to tow should have been as 3 to 1, but in point of fact it was only half good fibre and half tow. This defect was due to a want of skilfulness in manufacture. This point has an important bearing on the whole question, for the total money value of the yield depends very greatly upon skilful manufacture in order to create a good quality of flax with a low proportion of tow. The flax from the first year's experiments fetched £30 a ton, the second year £35, and this year it is expected to fetch £40 a ton owing to its better quality. The price of tow was about £10 a ton. The cost of production including cultivation, seed, manufacture, shipping, insurance, and other outlay expenditure, amounts to Rs. 62 per acre. Taking the 6 maunds of fibre to have sold at £25 a ton including tow, equal to say Rs. 13 per maund, we have a gross return of Rs. 78 per acre and a profit of Rs. 16.

This figure would appear to justify a continuation of the experiments and a moderate increase in the area under cultivation. Indeed Mr. Cameron, the manager, has stated that the experiments have paid almost from the beginning. It is, however, to be observed that the process of flax manufacture is a difficult one, involving a large amount of expert knowledge. It is evident from what was to be seen at Dooriah and from the figures supplied by the manager that the reason for such a low profit as Rs. 16 per acre is want of skilful manufacture. The question of cultivation can well be left to the planter and the native cultivators, for it has been

found that the plant can be grown satisfactorily. But the process of manufacture, that is to say the retting, the 'breaking' and 'scutching,' the assortment and packing for the market, cannot be performed properly by unskilled labour, and the difference between success or failure lies almost entirely in these operations. It is as cheap to manufacture well as badly, but the difference in the value of the results is very great. Badly made fibre will fetch only £25 to £30 a ton; well made fibre from £50 to £60. At the latter price the profit of Rs. 16 per acre would become Rs. 70 to Rs. 80, reckoning 4½ maunds of good quality fibre out of the 6 maunds per acre.

Reviewing the results of these experiments and those of the past 100 years, at what conclusion are we able to arrive? It would seem that flax can be grown and manufactured in India, but in order to make it a commercial success, the complicated and technical nature of the manufacturing process should not be left to amateurs, and the employment of instructors in the manufacture of the fibre is called for. We find the experiments of to-day giving as great a promise as those of the past hundred years; we find too in 1859 that Dr. Jameson, who so successfully carried on his experiments in the N.-W. P., wrote as follows :—"All that is required to market a useful crop in India are some good Instructors to show how the fibre is to be prepared and fitted for the market, and good seed and machinery. To encourage flax cultivation in Ireland, the Home Government annually allow the Royal Flax Society Rs. 10,000, and by this society upwards of £10,000 has been spent in twelve years in salaries to instructors, &c. If, therefore, the cultivators and preparers of flax in Ireland, where all the finest kinds of machinery are available, require instructors, how much more so is it necessary that means be adopted by the Indian Government to procure some expert Europeans from Europe to teach natives how to prepare fibre. Until this is done, it is in my opinion a useless waste of money to attempt to carry on the process with success .... but the experiment which was then going on so successfully, has been relinquished at the very time when it ought to have been prosecuted with renewed vigour."

History is again repeating itself in regard to the first portion of this statement. It would seem that the results of all these experiments, if they do not call for large undertakings, certainly engender the belief that the culture of flax in India would be a success if only instructors were on the spot to teach the skilful handling of the fibre, which seems to be the most important of all the conditions of success, and yet appears never to have been attempted on a reasonable scale. It should be observed also that the prospects of success now are greater than they were in those days. The demand for fibre all over the world has increased enormously, and the prices of to-day are

in every way more promising. There are two separate but closely connected problems for investigation ; *first*, the possibility of establishing a new industry for the growth of flax as a fibre crop for the production of high-grade fibre alone ; *second*, the possibility of introducing a system whereby fibre, probably of a lower quality, could be produced in combination with the existing large cultivation of linseed for oilseeds. The account given above shows that the first problem is being investigated in Behar ; the second problem has already received some attention at the Manjri (Poona) Government Farm, but without definite results. A more promising field for such trials is the Saugor-Nerbudda territory of the Central Provinces, where linseed naturally grows luxuriantly with a considerable length of stalk, much better than in the Bombay Deccan.

THE BENEFITS OF SHEEP DIPPING.

By Captain F. S. H. BALDREY, F.R.C.V.S., F.R.G.S.,

Fellow, Roy. Inst. Pub. Health.

Captain, C. V. D., Professor, Sanit. Scien., Lahore Vety. College.

During some twelve months' laboratory work in India, the enormous amount and serious nature of external parasitic disease amongst cattle and sheep have been very forcibly thrust upon me. I propose to give a short account of these affections as I have seen them, not from a professional and scientific point of view, which would be out of place in a journal of this nature, but from an industrial aspect in their relationship to agriculture.

I have found in the specimens of wool from sheep examined by me almost every known parasite that affects the skin of this animal. The commonest are, of course, the many varieties of ticks. There is the common red tick of the family *Ixodidæ*, its species being found in dogs, horses, cattle and other animals. It is characterised by its colour, the presence of a scutum (that is a small hard shell of a darker red colour, present on the superior and anterior surface), and its habit of remaining upon the one host from its larval stage until its full maturity, when it falls off to lay its eggs. It is a species of this tick (*Boophilus Australis*), which is most common in this country and which is the intermediary host of the disease known as Tick Fever, Texas Fever, or Red Water. This disease is indigenous in India, and is constantly demonstrated in the blood in the form of piroplasma, *i.e.*, a protozoon organism which attacks and enters the red corpuscles, either in the small variety first noticed by Lingard and called the *Piroplasma Tropica*, or in the ordinary form of *Piroplasma Bigeminum*, first noticed in this country by Raymond.

Another variety of tick, which has, I believe, not been before recognized in this country, is one of the species of *Argasidæ* of the family *Ixodidæ*, which is characterised by the absence of the scutum already described. They appear at first sight to be more like a wood louse in size and habit of movement, are grey in colour, and do not live permanently on the one host, *i.e.*, they will fall off and hide in a crevice of a wall and attack another

animal the next day or night. They are more nearly associated with fowls, and are the intermediary hosts of a disease of these birds known as *Spirillosis.* Theiller, in South Africa, has recently shown that they also convey a spirillum which affects cattle. The spirillum is an organism having powers of movement, which gains entrance to the blood-stream, but not into the corpuscular elements, causing fever, anæmia and death. It is a tick of this class which is associated with the disease known in the Punjab as *Chicheri ke bimari*, now being investigated at the Lahore Veterinary College. The variety and number of species of ticks of both the above big orders are very great, much investigation being required before we can expect to know and identify all of them. In view, however, of their great importance in the transmission of disease, this knowledge is absolutely essential.

Another common affection of the sheep is the presence of lice, the species found by me being *Hematopinus* and *Trichodralis* of the family *Pediculæ.* I have seen sheep literally covered with these parasites, and it is said by the natives that they cause death. From some of the cases that I have examined, this would seem to be quite possible, the wool and hides being so packed with lice that the irritation of their presence and the amount of blood sucked by them from their host would be sufficient to induce this result. The natives call this disease *Juree*, signifying lice. It is supposed to induce diarrhœa and death, but I have found that the cause of death is *Coccidiosis* or *Psorospermosis* which is an altogether different disease, although it is not known but what lice may have something to do with the infection as an intermediary host.

Ringworm seems to be more or less common also. The Superintendent, Civil Veterinary Department, Punjab, lately sent me some wool from an outbreak of what was supposed to be sheep scab, which was entirely ringworm of the *Tricophyton tonsurans* variety, almost every hair being affected. This is an affection, requiring much trouble to eradicate, and the loss is very considerable both in the lives of the sheep, and in the condition of the mutton and the fleece.

Finally there is ordinary sheep scab, due to the Acarus of that disease, (*Sarcoptes scabei ovis*), which is also more than ordinarily common in sheep, and a similar condition prevails in Buffaloes. It is looked upon by the native owner as an act of God for which there is no remedy. Imagine this condition in England or in any country where the raising of stock is conducted on modern principles.

I have given the above instances of disease in order to show the necessity for the recommendation which I wish to make for the introduction of the practice of sheep-dipping. It is a curious fact that the market prices of

most agricultural products of India are invariably lower than those of any other country. The prices of hides and wool are very poor as compared with Australia and America, and this seems mainly due to the careless condition of production in this country. The wool sent out is invariably the dirtiest in the market, the hides are badly saved, tick-eaten and inferior. All this is due to the indifference manifested in their preparation. As far as I can gather such a thing as a sheep dip has never been heard of, the ordinary precaution of having sheep dipped before the wool "clip" not even being thought of. This may possibly be due to the apathy which is characteristic of the country, but the want of any standard of excellence as an example has also a great deal to do with it. The reasons why India is not a much better stock raising country should be carefully considered. In comparison with other stock raising countries, the climatic conditions are not greatly worse in India. I have grilled in a tin-roofed hut in Queensland where it was necessary to allow 10—12 acres for each bullock and 6—8 acres for each sheep. Years ago I was stock riding in a similar country in the U. S. A., *viz.*, Arizona, where the summer heat is as trying as India, and feed is at times as scarce. But still these places are capable of producing meat, hides and wool of the first quality. A great deal of this inferiority of Indian products is due to the parasitic affections which are so exceedingly common amongst sheep, cattle and buffaloes. It is easy to imagine what deleterious effects the presence of these skin affections has not only upon the hides and wool, but also upon the animals themselves. The irritation set up inhibits the possibility of good condition, and the blood sucked is a serious debilitating loss, rendering the animal the more liable to attack by any contagious disease that may be prevalent at the time, especially as each bite of a parasitic insect causes a wound through which pathogenic organisms may gain admission.

There may be other factors which militate against a successful stock raising industry, such as the curtailment of grazing areas by the increase of cultivation. Such questions have been raised from time to time, but do not concern the point to which I wish now to draw attention. In fact, cultivation may have a beneficial effect on stock raising ; in the Argentine, huge tracts of alfalfa (lucerne) are put down for the grazing on most of the cattle and sheep runs, and in New Zealand artificial grazing of the very best quality has been introduced into the previously barren volcanic country by the sowing of clover.

As a means of reducing the ill effects of the above-mentioned parasitic affections, a system of clipping and regular dipping would appear to be indicated, whereby the external parasite would be removed, and some

of the diseases which they convey would be lessened. If only a few sheep were saved to each breeder in each year, an enormous surplus of stock would be gained, sufficient to provide all the Army Rations and other varieties of tinned mutton that are so extensively used in this country, not to mention the benefit accruing to the wool clip. This again suggests the possibility of establishing canning factories, and the increased trade which the industry would induce.

Indian stock raisers are not as a rule big owners ; they each possess comparatively few animals which all receive almost individual attention, being watched while grazing and under care at night. This would facilitate the introduction of a system of regular clipping and dipping. It would be easier to have animals clipped and dipped than is the case in the huge herds of eighty to a hundred thousand animals, as they exist in the Colonies and the Argentine ; and yet in these latter countries the thing is done without difficulty, although labour is at a very high premium. The practical application would not be difficult ; a dipping place could be arranged for amongst every two or more villages, where dipping could be carried out under trained supervision at regular intervals, as indicated and advised by Veterinary Superintendents. If necessary, a small fee might be charged to the owners in order to cover the expenses of the dip used, but for each individual sheep this would be infinitesimal, and would be paid for many times over from the benefits received. The inauguration of such a system would require the institution of some practical authority on the lines of the Stock Departments in Australia, or the Bureau of Animal Industry in the United States of America or the Agricultural Department in South Africa. A number of practical travelling Superintendents with expert veterinary knowledge would be required who could get quickly from place to place and see in what way the bad conditions which I have indicated could be ameliorated.

The chemical constituents used in the making of sheep dips and the method of mixing them in their proper proportions are hardly questions for this paper, but a system of dipping being now a recognized institution in most civilized countries, no difficulty would be experienced in obtaining full particulars as to the methods and their practical adaptation.

MANURIAL EXPERIMENTS WITH WHEAT AT THE NAGPUR EXPERIMENTAL FARM.

By D. CLOUSTON, B.SC.,

Deputy Director of Agriculture, C. P.

About the middle of last century Agricultural Science was only just beginning to investigate many of the most important questions relating to plant-nutrition and soil-chemistry. Thanks to careful experiment and scientific enquiry, much of that investigation has long since passed beyond the pale of mere theory, and has become part of a more or less exact science—the science of agriculture. The knowledge so obtained has become the foundation on which the principles of our best farm-practice of the present day are based. Only sixty years ago, however, our men of science had but touched the fringe of many of these great questions.

Liebig's Mineral Theory.—About that time, for instance, we find Liebig investigating the problem as to what really are the essential ingredients of plant food, and after much careful and laborious work in pot-cultures and soil-analyses, we find him expounding to the world his "Mineral Theory," that if you supply a plant with those mineral constituents found in its ash, as shown by its analysis, it will grow luxuriantly, because the air and soil together supply it with a sufficiency of carbon and nitrogen. He seemed to think that the ammonia of the air was an unfailing source of nitrogen, while in addition to this the plant has at its disposal the ammonia given off by decomposing vegetable matter.

M. Georges Ville.—Ville, though of the Liebig school, attached more importance to the need of supplying nitrogen to the growing plant. He includes it in what he calls his "Normal Manures," along with phosphoric acid, lime and potash; and states that, after much careful investigation into the results of his pot-cultures, he had arrived at the conclusion "that by the aid

of these four simple chemical products a maximum crop may be obtained from all plants in any place and in any condition of soil ; further that by varying the quantity of these products, the work of vegetation may be regulated almost like a machine, the usefulness of which is in proportion to the fuel consumed." Ville's theory then reduces itself to this, that to fit a soil for growing a crop you should see that these four essential constituents are there in sufficient quantity. Should it be deficient in any one of them, then that one should be applied as a chemical manure. But here a difficulty arises, for he had repeatedly found that soil-analyses were of little practical value. "Of what use is it to us to know that the soil contains phosphoric acid, potash, nitrogen, etc., if we consider active and inactive parts in the light of a loose and heterogeneous mass, as given in an ordinary analysis? No matter how exact in its details an analysis of the soil may be, it remains a dead letter with respect to the needs of plants, seeing that their roots are not provided with either acids, alkalies, or any other means of decomposing compounds, such as the chemist has at his disposal;" in other words the chemist at that time had not yet learned how to discriminate between the plant food which was immediately available in the soil, and that which only became available when treated with the strong acid solvents which he used in his analysis.

Ville's practical method of Soil Analysis.—Acting on the assumption that it was possible to bring the most barren soil to the highest degree of fertility by adding one or more of the four essential constituents, Ville devised a method for finding out which of these four are deficient in any one particular soil, and for any one particular crop. His was a thoroughly practical method of analysis. Five adjacent plots of equal area were chosen in the area to be considered. To the first plot no manure was applied ; to the second he applied the complete manure, *i.e.*, nitrogen, phosphates, potash and lime; while from the remaining three plots, one of the four manures was withheld in turn—only three being applied to each. The plots were all sown with the same crop. A typical experiment tried by Ville with wheat gave the following results :—

No Manure.	Complete Manure.	Minus Nitrogen.	Minus Phosphate.	Minus Potash.	Minus Lime.
720 lbs.	2,580 lbs.	840 lbs.	1,590 lbs.	1,860 lbs.	2,460 lbs.

From these results the following deductions can be made (i) that the soil requires above all a nitrogenous manure ; (ii) that it is deficient in

potash and still more in phosphates ; but (iii) that it already contains about enough lime for this special crop at least. In manuring such a soil for wheat, lime would be omitted altogether, but a heavy dose of some nitrogenous manure, along with a more moderate supply of phosphates and potash, would be necessary.

Experiments at Nagpur Farm.—Experiments of a similar character were initiated at the Nagpur Farm in the year 1883 by Mr. (now Sir Bampfylde) Fuller, who was Director of Agriculture at that time. They were continued for ten years with the one crop—wheat. During the first five years wheat was grown as a dry crop without irrigation, but the area was then changed and one to two waterings were given each season to the crop grown on the new area. The experiments may, then, be divided into two series. They were carried out with the greatest care, and the results obtained were proportionately valuable.

The aim of the investigation was to supply a much felt want, *viz.*, some definite information as to the fertility of "black cotton soil" for wheat. It was generally supposed to be rich, but whether in all, or only in some of the four essential constituents of plant food, no one then knew. It had been suggested that its fertility, like that of other Indian soils, might be due to a large amount of nitrogen obtained as ammonia in the rainfall. As recently as 1892, we find Dr. Voelcker hazarding the opinion that the soil of the Central Provinces did not require manure, and that that of the Nagpur Farm was too rich for experimental purposes. It is only fair to say that Dr. Voelcker had not had the opportunity of analysing samples of its soil ; nor, indeed, would any analysis have given much accurate or practical information as to its fertility at the stage which soil analysis had reached at that time. The Ville experiments of the farm were thus designed to solve a problem of a most practical and scientific nature — a problem, too, which up to that time had not received half the attention its importance deserved.

First Series of Experiments.—The first series of experiments dates from 1884 to 1889. The results of 1887 I omit, as the plots were overflooded that year, washing the highly soluble manures used from one plot to another, and giving results so discrepant that no deductions of any value can be made from that year's outturn. The fertilizers were employed in the following proportions per acre :—140 lbs. of ammonia chloride, 180 lbs. of superphosphate, 90 lbs. of sulphate of potash and 100 lbs. sulphate of lime. Their purity is not recorded, but the quantities used were supposed to be equal in amount to what a 1,260 lbs. crop of wheat per acre would make use of. The arrangement of the plots and the yield of grain in pounds per acre

during the first four years were as given below. The plots were each 1/20 of an acre in size—

Series I unirrigated.	Plot I	II	III	IV	V	VI
YEAR.	Complete Manure.	Phosphate omitted.	Nitrogen omitted.	No. Manure.	Potash omitted.	Lime omitted.
1883-4 ...	2,000	1,780	1,170	780	1,460	1,560
1884-5 ...	1,380	1,465	920	735	1,270	1,320
1885-6 ...	940	1,130	1,040	695	725	1,065
1888-9 ...	810	630	690	690	560	590
Average ...	1,283	1,251	955	725	1,004	1,134

Manurial results dependent on (i) Rainfall, (ii) Rust.—In examining these results what strikes one first is their marked irregularity from year to year in spite of the fact that the plots have had the same manurial treatment. Taking the unmanured plot as our standard, we find that the outturn in grain per acre of Plot I, with the complete manure, is nearly three times that of the standard plot in 1884, while in 1889, the fourth year of the series, it only exceeds it by a fifth or less. While Plot IV has only varied at the rate of 90 lbs. per acre, the variation in Plot I is actually at the rate of 1,220 lbs. In examining the meteorological conditions of the two years, we find that the abundant and regular rainfall of 1883-4 explains the bumper crops of that year. The manures applied were all dissolved and thus made available for the growing crop. In the fourth year owing to the lack of rain in September and October, followed by its complete failure during the winter months, all the plots germinated badly, while the manured ones could make but little use of the fertilizers which lay dry and powdery in an equally dry soil. Plot IV, depending as it did on its natural fertility, had less to lose, as the results clearly show.

Rust is another factor that goes far to mar the success that would, otherwise, attend the application of fertilizers to the wheat crop. In the third year of the series, for example, the heavy rains and cloudy weather of December and January brought on a virulent attack of rust, which reduced very much the gain from the use of manure in that year, while the unmanured plot suffered comparatively little. It seems that the more succulent crop forced up by manures is both a more attractive host-plant for this parasitic fungus, and also the crop being so much denser catches up far more of the wind-carried uredospores, than does a more straggling crop.

Deductions made from average outturns.—In spite of this irregularity in the results from year to year, due to the causes just explained, still,

taking the averages for the four years, we have sufficient data for broad and accurate conclusions. In the first place an average of only 725 lbs. or 12 bushels per acre from the unmanured plot, is, to put it mildly, certainly no indication of a naturally rich soil ; while the average increase of 557 lbs. or nearly 10 bushels got from Plot I is ample proof of the fact that the soil was originally lacking in fertility, and was for that reason very responsive to the application of the fertilizers. In other words Plot IV, which represents fairly well the natural fertility of the "black cotton soil" of the Nagpur country, is decidedly deficient in one or more of the four essential constituents of plant food.

Taking next the averages for Plots I, III, and IV, we notice that nitrogen accounts for an increase of no less than 328 lbs. over the unmanured plot. When it is added, Plot I yields 1,283 lbs., but when it is withheld, as in Plot III, the yields falls to 955 lbs. While nitrogen alone has been beneficial to the extent of an additional 328 lbs. of grain, the combined increase reaped from the other three, *viz.*, phosphates, potash and lime, only amounts to 230 lbs. Our second deduction then is that in the case of this particular soil, nitrogen is by far the most deficient constituent of plant food, and should, therefore, form the basis of every manurial dressing applied to wheat on such a soil.

The nitrogenous manure more effective on irrigated land.—If we now compare series (I) which was unirrigated, with series (II) the plots of which received one to two waterings each year, we note that under irrigation nitrogen is comparatively even more effective ; for while the three mineral fertilizers raise the outturn by only 11 lbs., the nitrogen of the ammonium chloride accounts for a gain of 413 lbs., as seen below—

Series II irrigated.	PLOT I.	II.	III.	IV.	V.	VI.
	Complete Manure.	Phosphate omitted.	Nitrogen omitted.	No Manure.	Potash omitted.	Lime omitted.
1890-91 ...	1,435	1,270	805	765	1,455	1,270
1891-92	1,230	1,500	710	710	1,440	1,240
1892-93	480	325	105	130	535	415
1893-94	786	799	430	374	606	782
1894-95	652	870	465	482	740	735
Averages ...	916	953	503	492	955	888

The one or two waterings were sufficient to dissolve the ammonium chloride, and in this state it was available to the growing crop, in spite of the conditions of drought which prevailed during the *rabi* season in 1893. That the average outturns of series II are nevertheless lower than those of series

I is due (*a*) to the crops of 1891, 1893 and 1894 being attacked by rust, and (*b*) to the fact that the field chosen as the site for these experiments had received no manure for the six years previous to its selection for this purpose. These two causes combined will explain the low average yield of 492 lbs. got from the unmanured plot.

Results given by the three mineral manures.—While the results of both series show a great uniformity in the splendid results given by all the plots to which nitrogen was given, we find those given by the mineral manures used are so erratic that no very definite conclusions as to their comparative merits can be drawn from them. At first sight one is apt to argue from the figures of Plot III of series II, that these three mineral foods are not deficient seeing that when all were applied and watered on that plot, they only raised the outturn by 11 lbs. over the unmanured plot. But this line of argument may manifestly prove to be fallacious, for as that plot had no nitrogen applied to it, it suffered from nitrogen starvation, and no matter how much other soluble plant food is added, the crop can make no use of it so long as there is no available nitrogen. Just as in the feeding of animals very much depends on the proportion between the nitrogenous and non-nitrogenous digestible constituents of food, and just as that ratio varies considerably for the different kinds of livestock, so the healthy growth of any one crop is determined by the "nutrient ratios" of the essential food constituents with which the soil is supplied. Hence the productiveness of a soil comes to depend entirely on that essential food which is present in the least proportion. Though Plot III has been abundantly supplied with phospate, potash and lime, these are of no avail so long as no definite proportion of nitrogen is applied along with them.

To estimate the relative values of these three mineral fertilizers we must see how the absence of each in turn affects the outturn. Taking first the average for Plot II of each series, we find that the effect produced by withholding superphosphate from the manure applied gives no definite results in favour of the use of that salt. No. II dry plot suffered an average loss of only 31 lbs. when it is omitted, while the wet plot actually did better without it. Phosphoric acid is evidently present in the soil of the Nagpur Farm in sufficient abundance to meet the requirements of any such cereal crop as wheat. This is not what one with a knowledge of western agriculture would have anticipated. British and American agriculturists who use chemical manures for wheat generally find that it pays to use phosphate in some form along with some nitrogenous manure. The fact that the ash of wheat grain contains 46 per cent. of phosphoric acid points to its importance for this crop. Comparing the averages of Plots V and VI with Plot I in both

series, it will be seen that while on the dry plot it is potash, on the wet plot it is the calcium sulphate that is the more beneficial ; on the whole the results will not justify the assumption that either is actually deficient in our "black cotton soil." Had they been deficient, then they should have exerted their full force on the wet plots to which they were applied ; but instead of that, the plot without potash gave on an average a better crop than did the complete manure on Plot I, while the average for the plot from which lime was withheld has suffered very little.

If the soil is not actually lacking in potash and lime, how then can we account for the fact that they have given an average increase of 278 and 148 lbs. respectively per acre on the dry plots? This may be due to either of two reasons, or more probably partly to both. They may have some small effect in forcing on the crop in virtue of the fact that they supply it with a very soluble and immediately available supply of plant food at the critical time at which it is most required. This is quite in keeping with our assumption that there was no pronounced lack of either to start with. But a second and more probable explanation of the results may be that the increases produced by these two manures are not so much due to their intrinsic values as plant food, as to their chemical effect in increasing the supply of nitrates in the dry soil ; for nitrogen is apparently the one ingredient which regulates the fertility of this particular soil. The saltish nature of the potassium sulphate, more especially, would to a small extent at least act as a solvent on the ammonium chloride.

Chemical and practical analysis compared.—Let us now compare the practical analysis with an up-to-date chemical one. In 1896 Dr. Leather made the four following analyses of soil from the Nagpur Experimental Farm :—

	Plot A-4 manured with 6 tons of cattle manure per acre per annum.		Plot A-8 manured with green hemp ploughed in annually.		Plot A-7 unmanured.		Typical sample.	
	Surface soil.	Sub soil.	Surface soil.	Sub-soil.	Surface soil.	Sub-soil.	Surface soil.	Sub-soil.
Total Nitrogen ...	·065	·033	·045	·033	·050	·047	·050	·047
Total Phosphoric Acid ..	·093	·065	·078	·058	·064	·054	·06	·05
Available Phosphoric Acid	·020	·008	·008	·004	·007	·005	...	...
Potash	...	..	..	..	...	...	·45	·51
Available Potash ...	·021	·010	·016	·010	·012	·010	...	...
Lime	...	..	...	...	...	...	1·82	1·76

These are, as far as I know, the only analyses available. Three of them are not very suitable for our purpose, seeing that they were taken from a series of continuous wheat experiments which had at that time been in progress for eleven years, so that in the case of the unmanured plot at least, the analysis represents the unexhausted fertility of the soil after eleven years' continuous cropping without manure. From the figures given we can calculate, though very roughly, what the initial fertility of that soil must have been.

Nitrogen.—In the first place we note that the total nitrogen is very low in all the plots. An average soil in England will contain about 0·1 per cent. of it. Dr. Dyer found 0·099 per cent. in the unmanured plot of the Rothamsted Wheat Experiments after it had given fifty crops in succession without manure, and the Rothamsted soil was just of an ordinary type when the experiments began, and certainly not richer in dormant plant food than the majority of heavy English soils. Compared with that soil, our figures for nitrogen are exceptionally low. After having its resources drained for fifty years, the Rothamsted soil still contains a half more total nitrogen than our "black cotton soil," which even as in plot A-6 has been fed up for eleven years at the rate of 6 tons of cattledung per acre; and it contains more than twice as much as our plot which had been continuously green-soiled for that time. That the total nitrogen in the green-soiled plot should be less than it is either in the unmanured or in the typical soil sample is, I confess, a great mystery to me. It would seem to point to a probable difference in the natural fertility of these plots to start with.

Lime.—Dr. Leather includes lime in only one of his analyses. His figures show that there is abundance of this ingredient. One half per cent. of lime in the first nine inches of soil is considered sufficient for arable land.

Potash.—Our chemical and practical methods of soil analysis are in complete agreement, then, as far as both the nitrogen and lime of the soil are concerned. They also agree in showing that there is a sufficiency of available potash. Dr. Dyer's method of analysis, on which Dr. Leather's was based, has shown that when an ordinary arable soil contains 0·01 per cent. of available potash and phosphoric acid respectively, in its surface layer of nine inches, it stands in no immediate need of special applications of these for cereal crops. Dr. Dyer used a one per cent. solution of citric acid as his solvent, and considered that its dissolving power on potash and phosphates represented fairly well the dissolving strength of the acid secretions of the roothairs of an ordinary crop. In a soil the potash and phosphoric acid soluble in this solution were, therefore, considered as "available" for the

crop. In no case, it will be seen, does the available potash fall so low as this standard.

Phosphoric acid.—Looking lastly at the percentages of available phosphoric acid as given in the chemical analyses, we find what at first sight appears to point to a marked discrepancy between the two methods of analysis. The analyses of plots A-8 and A-7 show only 0·008 and 0·007 per cent. of phosphoric acid respectively. These plots, however, do not fairly represent the average initial fertility of the soil of the Nagpur Farm, but only its fertility after having undergone a gradual exhaustion of its plant food by eleven years' continuous cropping. Still these results cannot be said to corroborate thoroughly the findings of the Ville Experiments. If there had been abundance of phosphoric acid in Plots A-8 and A-7 to start with, the 7 lbs. per acre or less removed by the crop annually would not account for the low figures shown by the chemical analyses, unless the amount lost by surface wash and drainage is very much greater in Indian soils than in an average English soil. In the case of the unmanured plot in the Broadbalk field of the Rothamsted Experiments, for instance, the percentage of available phosphoric acid in that soil of only average fertility was found to be 0·0078 after it had given fifty crops of wheat in succession. If the samples analysed were typical of the soil of the Nagpur Farm, then that soil must either have contained initially less than the normal quantity of available phosphoric acid for an average soil, or if it did contain abundance, it must have lost a considerable quantity that cannot be accounted for in the crops produced. English soils suffer very little loss of phosphoric acid by drainage, but the conditions here being different, may give different results. Perhaps some fresh light may be thrown on the question by the more representative analyses of our soils which are now being carried out, including as they do not only samples from plots exhausted by a twenty years' continuous cropping, but also samples typical of the soil's initial fertility.

The geological conditions of the soil.—It may be interesting now to see how our Ville Experiments harmonise with what we know of the general geological conditions of the Nagpur soil. The soil consists mainly of the debris of trap rock and reaches a depth of from five to six feet. It contains but few stones. Those that are found are commonly angular lumps of gneiss and lime stone and more nodular pieces of quartz of different degrees of purity, but generally coloured with iron. The soil when moist is dark in colour and changes to a darkish-grey on drying. The dark colour is due to the presence of certain colouring mineral matter and not to decayed vegetation as was formerly believed to be the case. What that colouring matter is

we leave to geologists to decide. The surface soil shows abundance of lime which exists in small seedlike specks in every lump of earth examined. When one of these lumps is placed in hydrochloric acid, great effervescence takes place, and on the lime being decomposed, the whole lump of earth crumbles down. The soil is fairly retentive of moisture and becomes very adhesive when wet, clinging to the sole of the boot with a putty-like persistency when one walks over it. On drying, it cracks freely to a depth of two or three feet. The immediate surface soil, too, crumbles down into a very fine tilth. Its sticky quality when wet, and its tendency to crack and pulverise when dry, are due to the presence of colloid material consisting of finely divided clay particles. These particles are coagulated by a clotting agent—carbonate of lime in this particular case. On drying, the soil cracks freely, and the surface becomes covered with an apparently coarser grained material than that of which the bulk of the soil is composed, forming a fine surface tilth. Being of a mineral origin it is deficient in organic matter, which is the chief source of a soil's nitrogen.

General conclusions—All our different methods of examination then lead to the same general conclusions, *viz.*, that our "black cotton soil" is only second class in quality, and that its great defect lies in its want of a sufficient supply of any form of nitrogen. It may be that in our tropical climate with the average temperature approaching the optimum for bacteriological action in the soil, the rapid decay of organic matter thus produced may be opposed to any accumulation of nitrogen. Undoubtedly the soil is rich in lime, too, which would facilitate the process of decomposition. To this is to be added the fact that the native cultivator is not in the habit of using manure. These three factors combined may explain the poverty-stricken state of our soil in nitrogen.

How we may most economically supply this nitrogen is evidently a question of the very greatest importance to the raiyat. Before recommending the use of highly soluble nitrogenous manures, we must prove in the first place that the cost of the manure is more than covered by the value of the increased produce, and in the second place that the soil suffers no deterioration when continuous applications are made. It was not the object of the Ville Experiments to investigate either. Attention may, however, be drawn to the apparent exhausting power of nitrogen as shown by the results of both series. Leaving out the results of the year 1892-3, which were abnormally low all round owing to a bad attack of rust, we note that with the exception of Plot II of series II, the outturns of the plot to which ammonium chloride was added, diminish faster than do those of other plots.

Taking the two series, and the initial year of each as 100, the results for successive years vary as follows :—

		I	II	III	IV	V	VI
Series I.	1883-4 ...	100	100	100	100	100	100
	1884-5 ...	69	82	79	94	87	85
	1885-6 ...	47	63·5	89	89	50	68
	1888-9 ...	40·5	35	59	88·5	38	38
	Loss ...	59·5%	65%	41%	11·5%	62%	62%
Series II.	1890-91 ...	100	100	100	100	100	100
	1891-92 ...	86	118	88	93	99	98
	1892-93 ...	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted
	1893-94 ...	55	63	53	49	42	62
	1894-95 ...	46	68·5	58	63	51	58
	Loss ...	54%	31·5%	42%	37%	49%	42%

It may be inferred that the addition of soluble nitrogenous salts, at any rate as chloride of ammonia, as manures on "black cotton soil" in India, is fatal to the future fertility of the land, but much more evidence is required before this inference can be accepted as a fact. In the Western Hemisphere the evil effect of nitrate of soda on certain soils is recognised by the intelligent farmer. When he continues to use it for cereals he finds that he generally gets a gradually diminishing yield from its use. This he sometimes wrongly attributes to a supposed injurious chemical effect that this manure has on the soil.

The object of the Ville Experiments, however, was merely to determine in which of the essential ingredients of plant food our "black cotton soil" is deficient. Questions relating to soil-exhaustion and to the most economical forms in which to apply nitrogen as a manure, have been investigated by another series of continuous manurial experiments with wheat which have been in progress for the last twenty years. A critical examination of the results of these will form the subject of a future article which, while showing the most profitable manures that the ordinary cultivator should use for wheat, will also throw new light on the question of how that soil has been affected by the continuous application of the different manures employed.

CO-OPERATIVE CREDIT IN BENGAL.

By W. R. GOURLAY, I.C.S.,

Registrar of Co-operative Credit Societies, Bengal.

WHILE the problem of the improvement of Indian agriculture is being attacked from the experimental and the research side by the Imperial and Provincial Departments of Agriculture, the more important question of financing the agriculturist has not been forgotten. It is remarkable that the industry by which over eighty per cent. of the population live is supplied with most of its capital at a rate of interest varying from 25 to 50 per cent. per annum. Any other industry would die under such conditions, but the agricultural industry cannot die; it is the ryot who dies. He cannot turn to a more lucrative occupation when agriculture does not pay; he either starves or becomes hopelessly indebted and the slave of the money-lender. If the problem of financing agriculture can be solved, the benefit to the ryot will be greater and more direct than the saving occasioned by new methods of agriculture or the profit to be gained from a greater outturn. Without the use of capital at a reasonable rate, the agriculturist will be unable to take advantage of new ways and means. The success of the results of research and experiment depend directly on the success of the effort to supply the ryot with capital at a reasonable rate.

Cheap capital or facile credit is not necessarily a boon in itself. Switzerland has organised a system of cheap credit with the result that 60 per cent. of the land is now mortgaged. The present and past generation have merely discovered a system of robbing future generations of a portion of their means of livelihood. Any increase in comfort has been obtained at the expense of their children's children. If credit of this kind were supplied to India, the ryot, who formerly was in a position to borrow Rs. 100 from his mahajan for his daughter's marriage and pay 50 per cent. per annum for the accommodation, would simply spend more on the marriage, and so land himself deeper in debt. With credit cheap he would purchase more.

The question has thus two sides, commercial and economic. A system of finance which might prove a commercial success would not necessarily

prove an economic success, but the system which promises to be an economic success must be based on commercial principles. The commercial side may be shortly stated thus:—the ryot is ready to borrow a sum of money for which he is at present paying interest from 25 to 50 per cent. or more; the majority of ryots have good security to offer for the sum which they require, while the capitalist has money to lend on good security at 6 per cent. These two have to be brought together for their mutual benefit. It would be easy and commercially profitable for the State to set up an agricultural bank provided with special summary powers for collecting its dues, but such a system would not benefit the agriculturist in the long run.

It is impossible for the large capitalist to come into direct contact with the small cultivator. The capitalist has no local knowledge of the individual, he has no agency for collecting small loans, and he could not keep millions of small accounts. There must be some intermediate organisations. In Germany this has been found in Co-operative Credit Societies, and in India an attempt is being made to create a similar organisation. This system aims at capitalizing the honesty of the villages. Where anything in the shape of a village community exists, the majority of the cultivators have a character for honesty, often not extending beyond the narrow limits of the village, but within these limits most transactions take place without any written bond, the man's word being sufficient. On this honesty a certain amount of credit is based; it may be a credit of only a few rupees, but the measure is known to the villagers. They know exactly how much a man ought to spend and how much he can earn. We want, therefore, to teach the people to amalgamate this village credit and jointly borrow a sum sufficient to meet the needs of the whole village. The capitalist does not know which cultivator is good for Rs. 5 and which for Rs. 100; he does not know who requires Rs. 20 to finance him and who requires three times that sum; he does not know who is already hopelessly involved and who can repay. It is the villagers alone who have all the information. On the other hand, the capitalist can see that the whole village is good for the total sum required. The ryots take the responsibility for dividing the money, of collecting principal and interest, and of keeping the separate accounts. This organisation of credit must be the bed rock on which any system of agricultural finance is based, and wherever a village exists, it will be found that the ryot's credit in his own village is better than his credit anywhere else. The individual may have a character for honesty in his caste, but his credit in his village will be greater than his credit with his caste.

There is no doubt that in this we have the germ of a solution of this great financial problem, but the question remains how to provide against

the evils of facile credit. By organising the village and making the members jointly and severally responsible, we create a check on excessive expenditure and prevent the individual from robbing his children. The village will not lend to the individual unless they see a prospect of the money being repaid within a reasonable time and, moreover, they will not lend unless they consider the expenditure necessary. A man is not tempted to spend on display more than he can afford when he has to run the gauntlet of public opinion, and the village will not lend him more than he can repay when they realise their joint responsibility. Further, there are so many necessary uses to which the members can put the money that they will not give out money for unnecessary expenditure, and if the member turns to the money-lender again, his name is removed and the privilege of borrowing at a low rate ceases.

There are at present in Bengal 86 experimental village societies, and the majority of these show every sign of ultimate success. These pioneer societies are distributed over twenty-two of the thirty-two districts in Bengal. The capital has been raised partly from Government and Wards' Estates and partly from private sources. The societies pay from 6 to $12\frac{1}{2}$ per cent. for the money borrowed, which they lend again at from $12\frac{1}{2}$ to $18\frac{3}{4}$ per cent. The whole of the profits go to a village fund from which the original capital borrowed will be repaid, and the village will then be in a position to carry on their society with a capital of their own sufficient for all ordinary seasons. Working on these lines, steady progress has been made during the last eighteen months. Wherever a village community can be found, the scheme will succeed, but in parts of Eastern Bengal where the cultivators do not live in villages, some modification will probably be necessary. The societies have been founded in villages which are not heavily indebted, because they offer the best field for initial effort, but as soon as the neighbouring villages see the benefit, they also demand similar societies in order to pay off their debts and start afresh. At present the societies are small, with a capital of Rs. 200 to Rs. 300, which is often sufficient to finance a small village, and such little societies are the best ground for observation and experience.

Three grain banks, run on co-operative lines by a zemindar of Dacca, have attracted much public interest, and it has been recommended that such *golas* should be opened all over the Province. The question of establishing grain *golas* is one of some difficulty, and so far only two have been registered in this Province. The price of grain ruled high this year, so that those with surplus stocks were eager to sell, while those with short crops had nothing to deposit. A grain bank requires much supervision, and it seems impossible to run it in Bengal as anything but a store of food grain. The different varieties of paddy sown by the cultivators of a single village are so very numerous

that the individual cannot rely for his seed upon the general stock in a grain bank. Under such conditions the only method of running a seed association is to purchase the variety of seed indented for by each member, and to use the collection in the *gola* as food grain. The ryots readily use mixed grain for food, but seed grain must be specially selected and true to variety. For the following year a sufficient quantity of the stock must be sold and the next year's seed grain purchased. The surplus stock must be sold as soon as the new year's grain is harvested, for paddy deteriorates after one year. All these little transactions mean a large amount of labour, and it is difficult to get rid of the custom whereby everyone who touches the grain gets a certain percentage. For these reasons I have come to the conclusion that on the whole it is easier to found successful money societies than seed banks; the temptations are fewer and the trouble of management is not so great.

At present, however, one experiment on a large scale is being made. In the Sonthal Parganas the Deputy Commissioner has carried on a grain-lending business for some years for the benefit of the ryots of the Government Estate and the Wards' Estates under his charge. There are *golas* at four centres with a total capital of nearly 25,000 maunds of paddy. Loans were made to individual cultivators, but the business soon assumed such proportions that it got beyond the management of the Deputy Commissioner without the assistance of a special staff. The defects of the system were the difficulties of checking the accounts and the stock; the high cost of the management owing to the payments made to headmen and others for collecting the debts; and lastly, the exactions at all times of weighment and check. In consequence the rate charged was not smaller than the rate at which the ryot could borrow from the village grain dealer. Under the new rules recently drawn up, loans will in future not be made to individuals, but only to batches of ten on the joint and several bond of the whole number. If any batch chooses, it may be registered as a co-operative society. In such cases the loan will be treated as the capital of the village bank and half the interest will be credited to the village; in other cases the full interest and capital must be paid annually direct into the central *gola*. Loans to societies are repayable in four equal annual instalments commencing from the end of the third year.

Success in all these experiments will not come at once. It is necessary to be patient. Raiffesen started his first bank in 1849, a second in 1854, and it was not till nearly forty years later that the movement made rapid strides. In Bengal there are already over three score societies working on sound principles, and this tends to show that we are on the road to a successful solution of the problem of financing agriculture.

CYANOGENESIS IN PLANTS.

By J. WALTER LEATHER, PH.D., F.I.C.,

Imperial Agricultural Chemist.

Of the experiments made in the chemical laboratory, many are carried from the stage of pure science to that utilitarian platform which makes the work serve the every day use of man. Cyanogenesis in plants is a case in point, as it has to do with a certain class of compounds which are a cause of occasional poisoning of farm animals. As the subject has a direct interest to the agriculturist, I propose to try to explain the nature of these compounds.

The chemist has constantly to use difficult words of numerous syllables each, but he is not alone in this practice. Other scientists offend equally as much in this matter. But if the chemist pleads guilty to the use of long words, he can at least offer the defence that the syllables have a definite meaning. The title of this article, due to Professor Wyndham Dunstan, is more readily appreciated if its derivation is explained. This is *cyanogen* and *genesis*. The latter requires no further remark; the former does. Cyanogen itself is of no very direct importance to the subject in hand, but the word occurs, and a near "relative" or "derivative," as the chemist says, will be spoken of.

The man in the street knows something about atoms; that they are the chemist's units of matter, and that they unite together to form groups which are called molecules. He knows, for instance, that water is formed by a grouping of two atoms of hydrogen with one of oxygen. But not only do atoms group themselves together to form molecules; individual groups of atoms may come as units and form a new substance. Take the simple case of respirating into lime-water. The air from the lungs includes the carbonic acid which is formed by the vital processes, and when brought into contact with the lime in the lime-water, these two, each consisting of a group of atoms, join together to form a new compound. This substance appears as a milkiness, and is the well-known chalk. Now we are very apt to say that chalk contains carbonic acid, because we

can again obtain the latter from the chalk, and yet this mode of expression is not strictly correct. Carbonic acid is a gas, whereas chalk is a solid uniform substance. Chalk is not quicklime nor is it carbonic acid, but is a new substance formed by the union of these two substances. I have chosen a familiar example in order to draw a distinction, which is all important to a proper understanding of my subject.

There is a well-known class of substances to which the name "glucoside" has been given. They are found in the tissues of plants. Indican, amygdalin and salicin are perhaps the best known. Whatever their origin or their individual properties, they possess two in common :—(*a*) if they are boiled with dilute acids, they are split up and two or more new substances are formed, one of which is always a sugar ; (*b*) this same change may be effected by the fermentative action of an enzyme, i.e., one of the so-called unorganised ferments.* Among the other new substances which result from this splitting process, there is always one which is characteristic of the glucoside. Indican yields indigo ; amygdalin yields oil of bitter almonds. Further, there is one series of glucosides which not only yields a sugar and a compound peculiar to each member of the series, but prussic acid in addition. Prussic acid is a derivative of cyanogen, and hence these glucosides have been termed cyanogenetic glucosides, because they are the origin of prussic acid. Until recently amygdalin was alone among the known glucosides characteristic of this property. But during the last two or three years others have been found. The list includes, among others, lotasin present in *Lotus arabicus*, dhurrin in *Andropogon sorghum*, phaseolunatin in the seeds of *Phaseolus lunatus*, gynocardin in the seeds of *Gynocardia odorata*, and that of the tapioca root which has not yet been fully examined.

The point which I set out to explain to the ordinary reader is then that there is a class of substances, the cyanogenetic glucosides, found in plants from which prussic acid may be obtained under certain specified conditions. On the other hand, they do not contain prussic acid. It is this distinction which I hope that I have made clear.

Prussic acid is a well-known poison. One grain is a fatal dose in man. Obviously then these cyanogenetic compounds, some of which are now known to be present in certain crops, possess a special interest to the agriculturist. For, although the farmer does not boil fodders with acid, if these peculiar substances are brought in contact with a suitable enzyme, the formation of prussic acid will ensue. And it so happens that with these glucosides, a suitable enzyme *is* generally present in the plant, not in the

* For a more complete discussion of this subject, see the article on the Study of Fermentation, Vol. I, page 68 *et seq.* of this Journal.

same cells, but in the same part of the plant. It is only necessary to crush almonds or jowari leaves or tapioca root in water, and allow the mixture to stand for a short time, in order to cause the change that I have spoken of. The mixture is then poisonous.

Another factor which in some cases is of great importance is that enzymes are destroyed by boiling water. It follows, therefore, that if a substance contains one of these glucosides and also an enzyme, in order to prevent the latter from having any effect on the former, it is only necessary to heat the material sufficiently for a short time, when all danger of the production of prussic acid will pass away.

We may now consider what is known regarding those cyanogenetic glucosides which occur in Indian crops. The first crop which we may notice is *Andropogon sorghum* (jowar, juari, cholum). This plant contains the glucoside *dhurrin*, situated principally in the leaves and stem. It is probable that as maturity approaches, the quantity of *dhurrin* decreases until it becomes negligible. It is accompanied by an enzyme, and it is only necessary to crush the plant in order to bring the two substances into contact and so cause the formation of prussic acid. The quantity of the latter depends entirely on that of the glucoside present. Usually it is only small, but occasionally it increases seriously. It is well known how poisonous sorghum fodder becomes at times. Suddenly the cattle are attacked with serious illness of which some die.

Whilst this general fact is established and the cause ascertained, the number of authentic cases in which the *poisonous* fodder has been examined are few. One such occurred near Poona in June 1904. The work bullocks at one of the Government Farms were suddenly attacked, a number became seriously ill, and two died. Some of the fodder was sent, after being partly air-dried, to the laboratory for examination. After crushing it with water and allowing it to stand overnight, 1·28 grain of prussic acid was obtained per one pound of green fodder. The same crop was examined a month later when the quantity of prussic acid obtained was ·75 grain per pound. There is no doubt that fodder containing so much of the glucoside as these figures indicate is poisonous to cattle. This crop was sown in March 1904, was grown under irrigation and had reached the flowering stage, when it affected the cattle so seriously. Naturally feeding with this fodder was stopped. But the crop was allowed to grow to full maturity; it was then harvested (July 11th), fully dried, and then fed later to cattle without any harmful effects.

There are two important questions relative to *dhurrin* in jowar. Under what conditions is the glucoside formed in large quantity? In what part of

the plant is it principally situated? Regarding the first, Brunnich carried out some experiments at Melbourne *, and he found that the glucoside was present in the plant at all stages of growth, but that its quantity diminished as maturity advanced. Also it is to be noted that the crop of jowar, which was so poisonous at Poona in June 1904, was quite innocuous after maturity. My own experiments on this point up to the present are very limited. In 1904, immediately after the case of sickness occurred at Poona, two varieties of jowar, namely "*Nilva*" and "*Utavali*" obtained from Poona, were sown at Dehra Dun, together with a local variety, and each was examined at intervals during August and September. The plants in all cases contained either no *dhurrin* or only nominal quantities of it. This experiment does not negative Dr. Brunnich's evidence, but it emphasises the fact that some jowar plants contain much more of the glucoside than others. In July 1904, a specimen of jowar fodder of the "*Hundi*" variety growing in the same neighbourhood as that which had done so much harm, was examined, and only ·17 grain of prussic acid was obtained from it per pound. Thus whilst the quantity probably decreases as maturity approaches, the really important question is, under what conditions is *dhurrin* occasionally formed in large amount in a crop of jowar, and why is the plant usually almost free from it? Regarding the second question, namely, in what part of the plant is *dhurrin* principally situated, the specimen of poisonous *hundi* was not only examined as a whole, but the leaves, stalks, and inflorescence were each examined separately (after drying in the air) with the result that the leaves produced 2·5 grain, the stalks 1·1 grain, and the flower ·25 grain of prussic acid per pound. The subject is, however, far from being completely understood, and I would be indebted to readers of this Journal if they would at any time send to the Agricultural Research Institute, Pusa, specimens of the fodder which are known to have been poisonous.

Lastly, it is to be noted that sun-drying the fodder does not decrease the amount of glucoside in it. On this point there is no doubt. Brunnich made a series of comparative experiments to test it, and in the laboratory of the Government of India, we have found similarly that the glucoside is not changed by this process.

Another plant common to India which contains a cyanogenetic glucoside is *Manihot utilissima*, the cassava or tapioca plant. The root of this plant has long been used as a human food, and in other countries both starch and tapioca are prepared from it. Authorities have generally recognised two

---

* Trans. Chem. Soc., 1903, page 788.

principal varieties, the "sweet" and the "bitter"; the former has been held to be non-poisonous, the latter poisonous, and the poisonous agent is known to be prussic acid. Some authorities state that the "bitter" varieties possess red petioles, the "sweet" varieties green ones. A considerable number of varieties were examined at Poona in January 1904, when I was able to establish three facts: firstly, *none* of the varieties contained any prussic acid as such; secondly, *all* the varieties, irrespective of the colour of the petiole or other botanical features, contained a cyanogenetic glucoside, which varied much in amount; thirdly, this glucoside is associated with an enzyme which has the property of causing the splitting up of the glucoside, and the consequent formation of prussic acid. As in the case of jowar leaves, it is only necessary to crush tapioca root with water in order to bring about this change. The amount of prussic acid varied very much; from some roots 1·5 grain of prussic acid per pound of root was obtained, from others only one-tenth as much. This root has to be considered both as a human food and also as a source of starch or tapioca. It is probably not eaten in the raw state in India, but it is sliced and fried in some parts as a vegetable. Whether this cooking process is sufficient to render the root harmless is uncertain. It would probably be so if fried in clarified butter (ghee). Boiling the root is quite sufficient not only to destroy the enzyme but also to allow the glucoside to pass out into the water, for the root splits up freely. On the other hand a misconception has occurred in the minds of some. I noticed the statement in one agricultural paper that since prussic acid is volatile, it is only necessary to expose the slices to the air in order to allow this toxic ingredient to vaporise. But this is far from being the case, and tapioca root slices might be allowed to remain exposed to the air for a long period without losing any appreciable portion of this constituent. The question has also frequently been put to me whether, in the preparation of starch, there is any risk of prussic acid remaining in it. The answer is very simple. When preparing starch the root is gratered, and there is no doubt of the formation of the prussic acid; but it is a soluble substance and must be carried away in the wash waters, so that the starch is ultimately quite free from it.

Besides these two crops I have obtained prussic acid from Rangoon Beans* (*Phaseolus lunatus*) and Val (*Dolichos lablab*) by simply allowing the crushed seeds to remain in cold water for a few hours. In the case of seeds their poisonous properties may be destroyed by boiling them in water.

---

* See Agricultural Ledger No. 2 of 1905, which contains an account of Prof. Dunstan's investigations.

It is also known that the linseed plant (*Linum usitatissimum*) possesses at times poisonous properties like sorghum, but cases of poisoning from this cause are rare. Whilst writing this article an instance of this has been brought to my notice by the Director of Agriculture, U. P. Some cattle belonging to a zemindar in the Banda District ate some immature linseed as fodder, with the result that fifty-two died in a few hours. The specimen of the plant which was sent to me contained a cyanogenetic glucoside and yielded prussic acid when crushed in water. I obtained 1·4 grain of the acid per one pound of the plant.

THE PRODUCTION OF EARLY-MATURING CANES.

By C. A. BARBER, M.A., F.L.S.,

Government Botanist, Madras.

SHORTLY after starting the Samalkota Sugar Station, a difficulty was experienced in dealing with the packages of canes received from various parts of the country when the local planting season had passed and no land was ready for their reception. Various methods of 'hatching' were tried, by which the canes, whole or cut up, were placed in shallow pits and covered up, but these did not satisfactorily overcome the difficulty and were found to give uncertain results in the soil of the Godavari delta especially after a long journey. A small nursery was, therefore, rapidly got into order and, following the method adopted in Ganjam, the sets were at once planted thickly as is done in paddy seed-beds. This method was perfectly successful, and the canes suffered in no way on being taken out and transplanted to the lands prepared for them.

About the same time attention was drawn to the Kistna delta, where, with excellent soil and an abundant irrigation from canals, no sugarcane at all is planted. While in the Godavari delta, however, irrigation is carried on for eleven months out of the twelve, the water is only available in the Kistna delta for nine months. If by some means we could reduce the period of growth of the canes to nine months, many thousands of acres would be available for this valuable crop. The way to this appeared to be opened by the nursery experiment above mentioned.

These facts led to the study on the farm of various methods of producing early-maturing canes. Although the work is still in its infancy, and exact analyses have not been accumulated in sufficient quantity to demonstrate every point, enough material has been collected to make it desirable to draw the attention of workers to this line of experiment. It is hoped especially that cane growers living in regions of limited irrigation may take the matter up and make further experiments not possible in rich delta lands.

The nursery method of propagation has been introduced successfully into various parts of the Madras Presidency. By it we were able last year

on the Samalkota farm to plant up thirteen times the area of the seed-bed, and, while this cannot be done in all cases, it is evident that the land to be finally planted may be many times as large as the nursery. It is frequently possible to set aside an acre of land under a well close to the village site and plant this at a time when general agricultural operations are out of the question. Such an area would furnish seed cane for quite a large field, and the period of water scarcity could thus be bridged over from one season of irrigation or rainfall to another.

In the latest experiment on the farm, the seed-bed was planted on the 29th March 1905, and the young canes were transplanted on the 4th of June. The canes were analysed once a fortnight from the beginning of December until the harvest. They were judged to be ripe eight months after the time of transplanting. Compared with similar plots planted with sets from the beginning, the length of time from planting to reaping was the same. The period of growth in the field, saved by the experiment, was therefore exactly equal to the time spent in the nursery. We cannot say whether this would always be the case, and it is at least doubtful whether the crop would be as good as in ordinary planting,—probably not. Comparative experiments have still to be made on the subject, but there are some indications that the produce of seed-bed canes has a certain resemblance to ratoons or second-year canes.

The importance of this method of planting canes cannot be over-rated in places where the period of irrigation is short, or where the exact date of the advent of seasonal rains cannot be foretold. There is no longer any need for keeping the cane standing in the field (standovers) month after month, in the hope of rain coming. The cane sets may be cut at the time of harvest and immediately planted in a nursery, the land intended for the crop may be prepared in a more leisurely manner and the canes transplanted when it is ready and when the danger of a water famine has been averted.*

"Stool-planting" is another method adopted at the Samalkota farm. After the canes are cut, the "roots" (more properly called stools) have to be removed for the preparation of the land for the succeeding crop. If these stools are cut up they may be planted without danger. Supposing the canes were originally planted at the rate of 10,000 to the acre, the stools therefrom may be made to plant up five times the area. For it has been found in trials on the farm that, owing to the invariable and rapid growth of all the divided stools, they may be economically put in at the rate of 5,000 to the acre, and that each stool will provide at least two or three plants.

* Some other advantages of a nursery may be noticed. Many, if not all, diseased sets can be eliminated; and a more uniform stand of canes can be obtained.—*Editor*.

By this method of stool-planting the period of water scarcity can also be partially bridged. If the canes are cut in the ordinary course, the stumps will remain in the ground for a considerable time without dying and thus a part of the time of short water may be passed. Moreover, the stools mature earlier than plant canes, so that their period in the ground is shorter. The exact advantages of this method of cane-planting have not been fully worked out, and will probably vary a good deal in different parts of the country. One of the greatest is that, with proper care, no filling up of blanks will be needed. A full stand can be obtained at the start, a very important matter in successful cane cultivation. The plots planted in this way resemble ratoons even more than those planted from seed-beds, and the yield is probably less than from plant canes. On the other hand, the old roots are utilised as seed, and the canes are far more healthy than ratoons. The plants are not so long a time in the ground, as stool-planted plots ripen earlier than those planted from sets. This agrees with the well-known character of ratoons which, in the Godavari district, mature one month earlier than plant canes.

"Trashing" or stripping the canes of their dead leaves, so frequently done in moist lands in the West Indies, was tried on the farm, and the canes in one experiment ripened a month earlier than in the control plot treated in the ordinary way. The experiment is isolated and therefore not conclusive, but the result is in the direction that would naturally be expected. More experience is necessary before the method can be recommended under Indian conditions. Its usefulness will probably vary in different tracts, and where the canes are liable to be attacked by jackals or where the atmosphere is very hot, it is less likely to be advantageous. To take the case of the Godavari delta, the canes are heavily wrapped round with their own dead and dying leaves to bamboos and to one another. This at first sight appears to be an unreasonable practice. But when one considers the great height to which the canes grow in good crops (some canes last year, when laid out, measured 26½ feet in length over all), and the violent storms which usually occurs towards the ripening time, as well as the frequency with which the canes are attacked by numerous jackals and wild cats, it is difficult at present to suggest any certain improvement. Trashing can only be done with hard-rinded canes of a bunching habit.

The feeding of the cane and its general treatment have a great influence on the time required for ripening. It may be stated generally that, when starved, its growth is limited and ripening is hastened. The manurial plots on the Samalkota farm have been of a comparatively simple nature, being mainly devoted to the comparison of the effect of different

quantities of nitrogenous food in the form of oil-cakes. Analyses made at intervals for some months before harvesting have shown very conclusively the effect of such manures on the ripening of the canes in the heavy delta lands. In each and every case the rate of ripening was retarded in proportion to the excess of nitrogen in the manure. When a heavy dressing of oil-cake was supplied the crop was of great bulk, but the canes had not ripened after a full twelve months, whereas in the case of the application of ordinary "village manure," the canes ripened in 9 to 10 months. The application of manures must then be carefully considered, and nitrogenous manures in the form of oil-cake must not be given in too large quantities when it is desired to shorten the period of the cane's growth.

This latter fact brings us to the conclusion that it is generally useless to expect very large yields with a short period of cane growth, and that efforts at reducing the time in the ground are likely to be accompanied by a diminished yield. It may be stated as a general rule that, within certain limits, the longer the cane is in the ground the larger is the crop. It should be noted for instance that the enormous yields quoted from New South Wales are stated to be from canes 18 months old. In the same way some *Mogali* canes recently distributed from the Samalkota farm to a planter in Mysore were reported to produce 6⅔ tons of jaggery to the acre at 18 months. This is the converse side of the problem. There are comparatively few places where the canes can be successfully grown for much more than a year, but it may be quite worth while to consider in special cases whether it will not be more economical to lengthen the period of growth instead of restricting it.

In conclusion, there is no doubt that certain canes require a longer period for their growth and maturity than others, although this subject is still rather obscure. The rate of ripening is obviously one of the first factors to be determined when introducing canes to fresh localities. There is great activity just now in bringing canes from the ends of the earth and trying them in various places suitable and the reverse. While some of these efforts will succeed, others will undoubtedly fail, and a record of these successes and failures will be of use in judging which canes are suited to which conditions. This opens a great field for observation which should not be left to the agricultural departments alone, but in which every cane grower should take part.

THE STUDY OF FERMENTATION AS APPLIED TO AGRICULTURE.

By C. BERGTHEIL,

Bacteriologist, Agricultural Research Institute, Pusa.

(PART II.)

IN a previous article (*Agricultural Journal of India*, page 68, Vol. I), the study of fermentation was defined as the chemical changes which take place under the influence of living matter, and it was stated how essential this study has become to modern agricultural science, particularly in the endeavour to obtain a more intimate knowledge of the vital activities of plants. It is necessary to follow the matter a stage further than this, and to learn what is possible about the processes, which take place after the plant has ceased to grow and its substance is undergoing fermentative change. In the present article it is proposed to amplify this latter theme by considering a few special problems and to show how their study has led, or may lead, to practical results.

The term 'fermentation' naturally suggests to the lay mind something connected with spirits, and it was indeed in connection with operations involving the production of alcohol that the term was originally used. A consideration of the processes of spirit manufacture will serve to illustrate the type of problems which, though they have assumed an importance justifying a special technology of their own, are very closely allied to agriculture, since all the raw materials concerned are derived from the land.

Amongst all races and in every age we find a knowledge of some means for the production of alcoholic spirit, all fundamentally depending on the fermentation of sugar. A real understanding of the processes involved is, however, comparatively recent, and it is only by the aid of our modern conceptions of fermentation that the connection between agriculture and the manufacture of spirit has become clear. In many of the processes concerned, more especially those used in Western countries, we have to deal with

an enzyme action at the very beginning. Here the raw material is commonly some kind of grain, such as barley or rye, or some starchy tuber, such as the potato, all of which contain no sugar or only a very small quantity. The first operation necessary is the production of sugar from the starchy material. For this purpose, use is made of an enzyme action of a precisely similar kind to those mentioned in our previous article in discussing the germination of the seed ; in fact, the process employed is nothing else than the utilization of Nature's effort to promote the germination of the grain by supplying the embryonic plant with easily assimilable food. All starchy grains contain, and have the power of producing, a specific enzyme "diastase," whose special function is the conversion of the insoluble starch into a soluble sugar, and it is only necessary to put the grain under suitable conditions of moisture and temperature to promote the interaction of these substances and the resulting formation of sugar.

This is the preliminary operation of practically all processes of alcohol production from grain, and is exemplified by the so-called "malting" of barley preparatory to the preparation of beer or whisky. In this process the barley grains are placed under conditions favourable for germination and are allowed to grow until they have extended a shoot about half to three-quarters as long as the grain. By this time the maximum amount of diastase has been produced and the maximum amount of starch has been converted into sugar ; the process is, therefore, concluded by heating the germinated grain to stop its growth, for otherwise the sugar produced would be assimilated by the young plant and the maltster's object be frustrated. In the case of potato spirit, the operation is similar, except that here diastase has to be produced from grain as described above and introduced into the mass of potato starch as "malt," whilst, in the case of the Japanese "Moto," which is an alcoholic spirit made from rice, and of "saké" which is a beer prepared from the same material, we have a still more marked instance of the introduction of enzyme from an outside source, since reliance is placed entirely on diastase produced by a mould, with which the boiled rice is infected to bring about the necessary saccharification.

Modern study has taught us a great deal about the enzyme actions involved in these various processes. In the first place we have learnt that starch is the essential constituent of the many types of raw material from which alcohol is eventually derived and that, therefore, the production of a highly starchy grain (which, within limits, has also a correspondingly great diastase-secreting power) is the chief agricultural desideratum from the brewer's and distiller's points of view. This, of course, depends upon the plant selected for the purpose, on the soil in which it is grown and

its manurial treatment, so that pure agriculture is very closely concerned in the matter. Much has been learnt too of the effects produced by the other constituents of the materials used, by the bodies formed during the process and by the various conditions of environment (heat, moisture, acidity and the like), on the saccharifying processes. In every case the question must be considered from the point of view of enzyme action, and so much time and labour has been devoted to the study of this particular operation in the past that diastase is to-day by far the best known of all enzymes, and processes involving its use can be regulated with almost the exactitude of an ordinary chemical reaction.

It would be beyond the scope of the present article to go further into the detail of the preliminary operations involved in the manufacture of spirit. We have seen that the prime object of them all is the conversion of starch into sugar, and we will now consider the formation of alcohol from the sugar so obtained. Here we have to deal with a fermentation process which serves well to illustrate the view expressed in the previous article that the essential nature of all fermentations, whether produced by so-called 'organized' or 'unorganized' ferments, is probably the same, both being due to enzyme action. As is well known, alcohol is invariably produced industrially from saccharine liquids by the action of yeasts, lowly organisms closely allied to moulds, which possess the function of converting sugar into alcohol. In Western countries yeasts and their actions have been most carefully studied, and pure cultures of special yeasts, which have been found most suitable for the production of the particular type of fermentation desired, are deliberately introduced and their growth most carefully regulated and guarded ; in other cases, such as those we are familiar with in India, wild yeasts are allowed to gain access from the air and grow in the liquid to be fermented, but under all circumstances a yeast or closely allied organism is necessary to the process. Until recently it was believed that this action of yeast in converting sugar into alcohol was due to some vital action of its protoplasm as distinct from a secretion of enzyme, and it was invariably cited as an instance in support of their views by those scientists who hold that there are some types of fermentation produced by mycro-organisms which are independent of enzyme action and depend on some other type of metabolic operation of their cell-contents. The existence of an enzyme capable of converting sugar into alcohol in yeast cells was, however, conclusively proved in 1897 by Buchner, who succeeded in extracting it by submitting the cells to great pressure. In this way a clean liquid was obtained which, on being added to sugar solution, produced the evolution of carbonic acid gas characteristic of alcoholic

fermentation and the formation of alcohol in the liquid. The difficulty which had previously been found in extracting the enzyme was thus shown to have been due to the great tenacity with which it is held by the yeast cell-contents. It was found that a white solid could be precipitated from the liquid extracted from the cells, which was soluble in water and whose solution acted upon sugar exactly like the original extract ; this solid represented the enzyme in a crude state and has been called "zymase" by its discoverer. So far this has had no pronounced influence on the industries concerned, it being still found more convenient to allow the yeast cell to elaborate the enzyme in the liquid to be fermented and produce the desired action, but the discovery is important from the theoretical point of view and suggestive of a line of investigation along which many other fermentative changes induced by organisms may be, and are being, studied with a prospect of obtaining a more intimate knowledge of their nature.

We have, however, occupied more space than the subject justifies by the consideration of alcoholic fermentation which, though it is connected very closely with agriculture, has been made the subject of so much special study that it has been well nigh removed from the sphere of the agriculturist. Problems with which he is more intimately concerned are those of the dairy.

Milk and cream are naturally ideal media for the development of organisms, so much so that a sample of cream ripe for butter-making has been found to contain as many as 1,500,000,000 bacteria per cubic centimetre, far more than those found in sewage or any other natural material which has been examined. It, therefore, becomes a matter of great industrial importance to preserve milk from harmful fermentations, particularly those occasioned by pathogenic organisms, and considerable attention has been devoted to this question in the past. The result has been the introduction of the system of "pasteurization," now so widely used in Europe and America, by which the milk is heated to a sufficiently high temperature to destroy most, if not all, pathogenic bacteria and a great many of those which occasion the rapid "souring" of milk not so heated, whilst avoiding the undesirable changes in flavour and chemical composition which would be produced by boiling.

In India where milk is a staple article of diet, where epidemic disease is rampant and the conditions of climate so suitable for the development of all bacterial growth, this question should demand special attention. The milk-man of India is well aware of the desirability of boiling his milk in hot weather to prevent it 'souring', but the importance of placing the milk in a clean vessel when boiled, and the dangers incurred if he does not do so, are by no means present to his mind. Much might perhaps be done by instruction and guidance in this direction.

In the manufacture of butter and cheese, a great many fermentation problems arise, which modern study has partly elucidated but many of which are still unsolved. In Denmark and America, where these subjects have been very thoroughly investigated, the bacteria which operate in the ripening processes of butter and cheese have been isolated and identified, and pure cultures of these organisms are used to promote these operations just as we have seen pure cultures of yeasts used in alcohol production, the result being a very much more economical method of working and products of very much finer and more easily regulated flavour than those previously obtained by leaving the fermentation processes to more or less chance organisms. Research has shown too that enzymes play a very important part in the dairy, since they are contained in normal milk as excreted and are responsible for a very large part of the changes which the milk undergoes in its subsequent conversion into butter and cheese. The preservation of butter also demands as close study as that of milk, and here again not only are bacterial problems involved but also a consideration of enzymes, which undoubtedly play a part in producing rancidity.

The bearing of these questions on Indian practice is at present unknown, but if dairying is ever to be an industry of any magnitude in India, and there seems no obvious reason why it should not, they will have to be reconsidered with regard to the special conditions holding in this country and the peculiar methods which native practice has evolved.

The question of the preservation of milk and butter products naturally leads to a consideration of that of other farm products. In almost every farming industry it is necessary to keep some kind of produce, particularly cattle food, after it is gathered until it is required for use, whilst it is absolutely essential to store some crops to render them suitable for food at all. In the methods used for this purpose we have to deal with several distinct types of fermentation. On the one hand we have to guard against the invasion of the stored material by harmful organisms as in the case of milk and butter, and on the other hand we have to encourage certain types of both bacterial and enzymic fermentations which lead to the production of a more stable or more palatable food. The preparation of ensilage is a good example of this. This process, by which green fodder may be preserved for long periods without loss of material and without ceasing to be good food, has been evolved as an outcome of the necessity for storing crops obtained during the summer months for winter feeding. The best method of attaining the desired end has been learnt by experience. It consists merely in placing the chopped

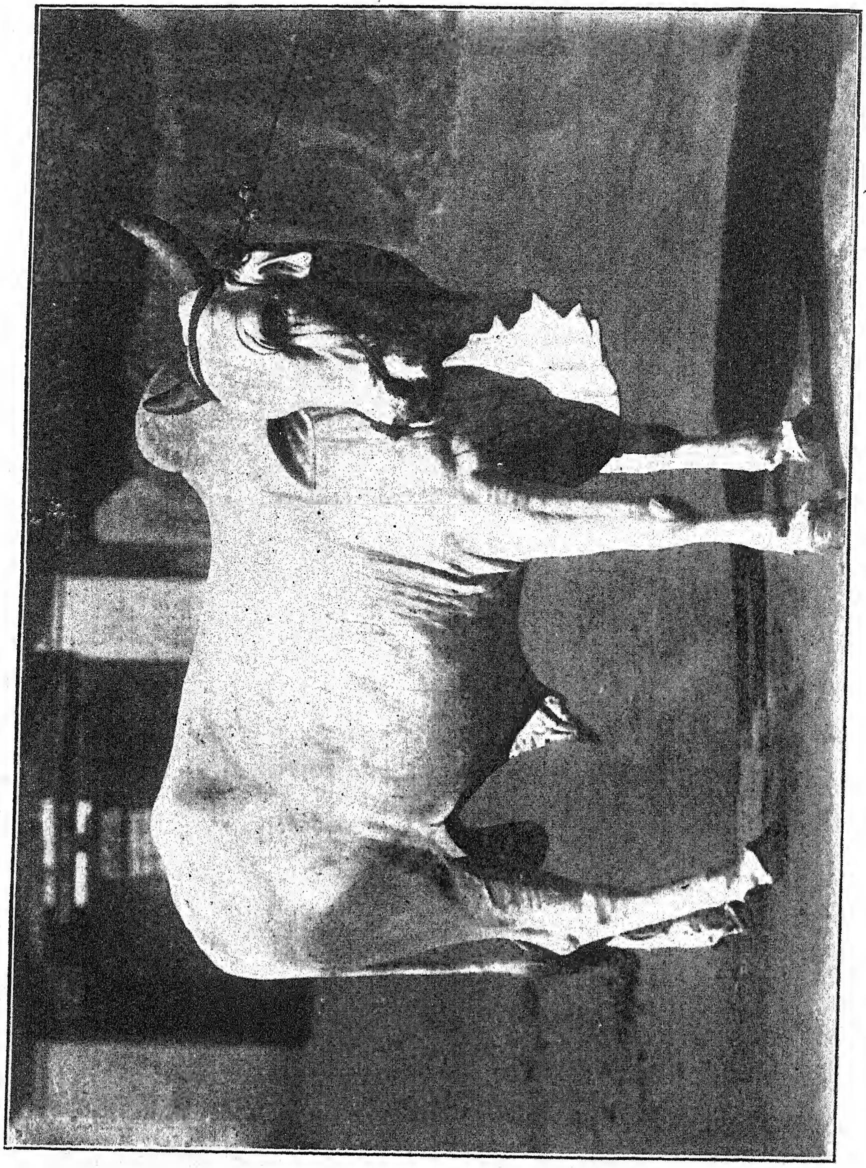
green food into large masonry towers from which all air can be excluded and packing it down very tightly. Only in recent years have the underlying principles been investigated and the procedure established on a rational basis, but we are probably still ignorant of many essential factors in the process. Originally the changes which take place in the material in the silos were attributed entirely to bacteria, it being supposed that aerobic bacteria operated in the first stages until all the air was exhausted from the tightly packed material, and that anaerobic organisms then concluded the process and were actually responsible for the changes produced. Modern investigation has, however, shown that this is not so and has made the probability strong that the preservation is due to some vital activity of the plant itself, which may or may not be exercised through the agency of enzymes. Certain it is that foreign bacteria must be excluded and the material so packed that they can gain no access. The chemical changes which take place in the material stored are profound and well merit further investigation, not only by reason of their theoretical interest but in order that their complete understanding may place us in a position to modify and adapt the method to conditions under which it has not yet been tried.

Probably similar courses of action take place during the storage of other food products. We know of many cases in which the crops as obtained from the land cannot be fed direct to stock without grave risk to health, whilst a few months' storage will render them excellent food. Mangel-wurzels afford a good example of this. The reason of the change has not yet been explained, though it is well known that the chemical composition is altered during the storage, and it is likely that it will be found due to fermentative action and subject perhaps to scientific control when understood.

Another branch of industry connected with agriculture in India, and one in which fermentation studies may lead to results of the greatest practical value, is the manufacture of textile fibres. India is remarkably rich in fibre-yielding plants and affords ideal climates for their cultivation, but hitherto difficulties in the way of preparing the fibres have stood in the way of the creation of really great industries. Jute is perhaps the solitary exception, and here we have a process of fibre extraction handed down from posterity and based, like so many other industrial processes, on little more than rule of thumb. Bacteriological study may throw some light on the question of jute retting and perhaps lead to the production of a fibre of higher value, but the principles evolved should be extended to other fibre plants, which promise to yield products of greater worth but which cannot be economically prepared by mechanical means.

In the previous article the fermentation of tobacco, tea and indigo were mentioned as types of those which must be studied. These are instances of true enzyme fermentations, though they were for many years considered dependent on bacterial action. It is not proposed to discuss them here. Sufficient has been said to show how wide and varied are the applications of fermentation studies to agriculture and the immediately kindred industries.

PLATE XVI.



NELLORE BULL.

A. J. I.

THE NELLORE BREED OF CATTLE.

By Major W. D. GUNN, M.R.C.V.S.,

Superintendent, Civil Veterinary Department, Madras.

The Nellore breed of cattle has a wide reputation throughout India and even beyond its limits. Formerly the principal breeding localities were situated within the Northern Taluks of the Nellore District of the Madras Presidency, but recently these taluks have been included in the new District of Guntur, so the cattle should not rightly be given the name of Nellore, but rather that of Ongole, from which tract the best specimens of the breed are to be obtained.

It was formerly noticeable that cattle breeding received most attention in those parts of the country where circumstances of one kind or another were adverse to the extensive prosecution of agriculture. The cultivators were repeatedly deprived of the results of their labour, and were consequently considerably harassed : they, therefore, as a substitute devoted their time to raising large herds of cattle of a superior kind which were then much in demand, and which they saved from the grasp of the officials by moving them from place to place. Under more secure Government, these cattle breeders settled down, and being a fairly wealthy class, retained their pride in the fine cattle in their possession, with the result that many beautiful specimens may now be seen in this part of the country. The very best examples are to be found in the villages of Karumanchi, Nidamanur, Pondur, Jayavaram, Tungutur and Karavadi in the Ongole Taluk, and in Elapalapadan, Nennurpad and the hamlets along the banks of the Musi in the Kandakur Taluk. Fine cattle of this breed may also be found in the Taluks of Vinukonda and Narsaraopet in the Kistna District. In the southern part of the Nellore District where wet crops are grown, the cattle are much inferior, not being so well cared for or fed as in the places above named.

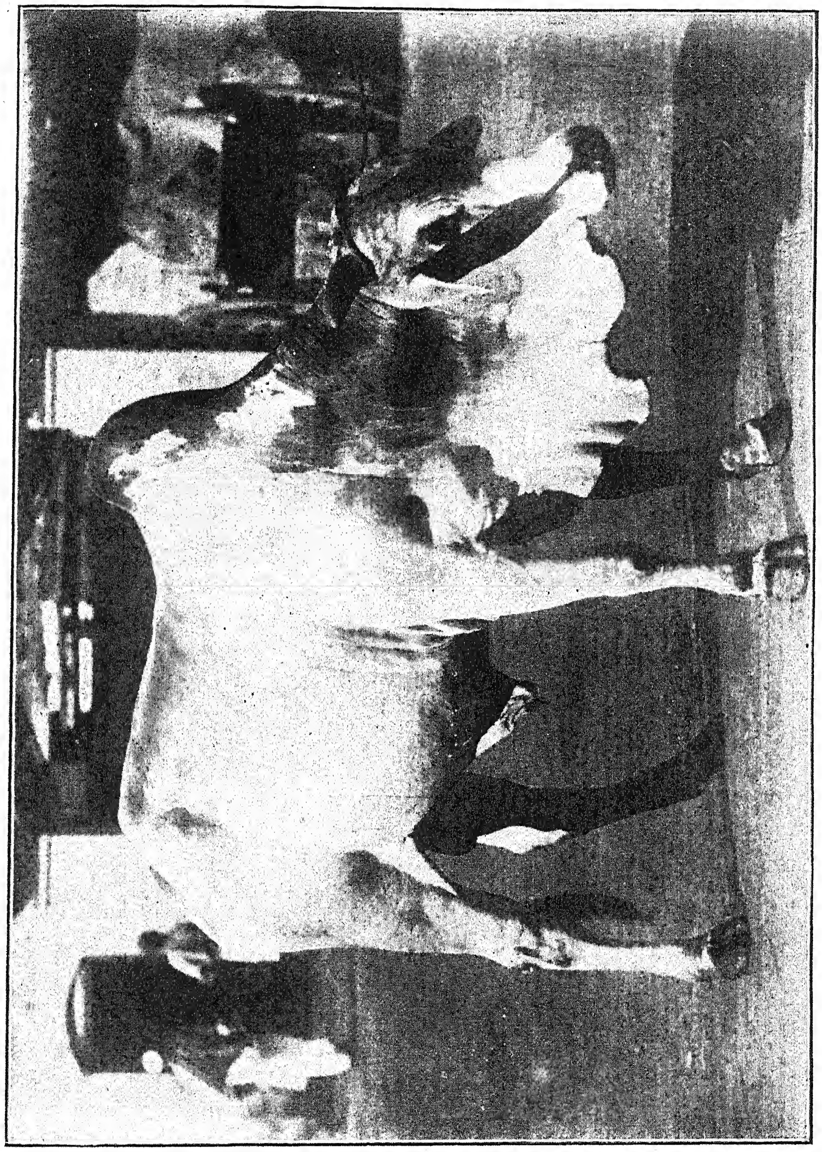
The system of feeding observed by the ryots of the different parts of this country naturally depends upon the extent of the pasturage. In the low-lying parts where paddy is principally grown, a certain portion of dry

land is often kept as a pasturage for cattle. Most of the cattle, however, leave the villages during September and October—the southern rainy season —and are sent to the Western Taluks where there are extensive waste and jungle tracts. Part of the working cattle will occasionally follow the other cattle during November and December, should the pasture land of the village not be sufficient. The ryots often club together and send their cattle away in large herds. For this purpose, prior to the departure of the cattle from the village, arrangements are made for renting pasture blocks at a fixed sum for the season (October to February), or engagements are entered into with the holders of the pasture farms for the pasturing of the whole herd for the season at a small fee per head for each full-grown animal. Should the North-East monsoon be favourable and extend till late in the season, the cattle are only pastured until January when the paddy is harvested, after which there is very fair grazing. The whole of the jungle grazing is not open to the cattle at all times, for after a heavy burst of rain, invariably experienced about October, the best portion of the pasturage is preserved and kept clear of cattle for one or two months until the grass has grown up well, when the working cattle alone are turned in and kept thereon so long as the pasturage suffices, another portion being similarly kept for the other cattle. Towards the end of January, when the sorghum crop on the higher land has come into ear, the young shoots termed *Zadu*, which are not likely to mature, are removed and given to the bullocks, which are often picketed close to the fields. Occasionally fields in the midst of cultivation are set apart for pasture and are planted with the black and white varieties of *Acacia*. After being under grass for ten or twelve years, the ground is cleared of trees and broken up for cultivation. The trees shade the ground and favour the growth of grass, whilst the pods form good fodder. The pasture land held in this way is invariably distinct for each ryot and is generally kept exclusively for working cattle, young stock and milch cows.

The country where the best cattle are raised is undulating highland interspersed with small hills, and is mostly composed of light red or dark alluvial soil, where good sorghum, other millets and legumes are raised. The well-to-do ryots in these parts find their pleasure and pride in raising fine cattle.

There is no greater truism than that which refers to the necessity of feeding young stock, and the very great care which the best breeders bestow on their young animals, both male and female, most certainly accounts for the well-deserved reputation of the Ongole cattle. The young calves are allowed to suckle the whole of the cows' milk, and when they are three months old are given grass and a small ration of mixed grains. In every

PLATE XVII.



NELLORE BULL.

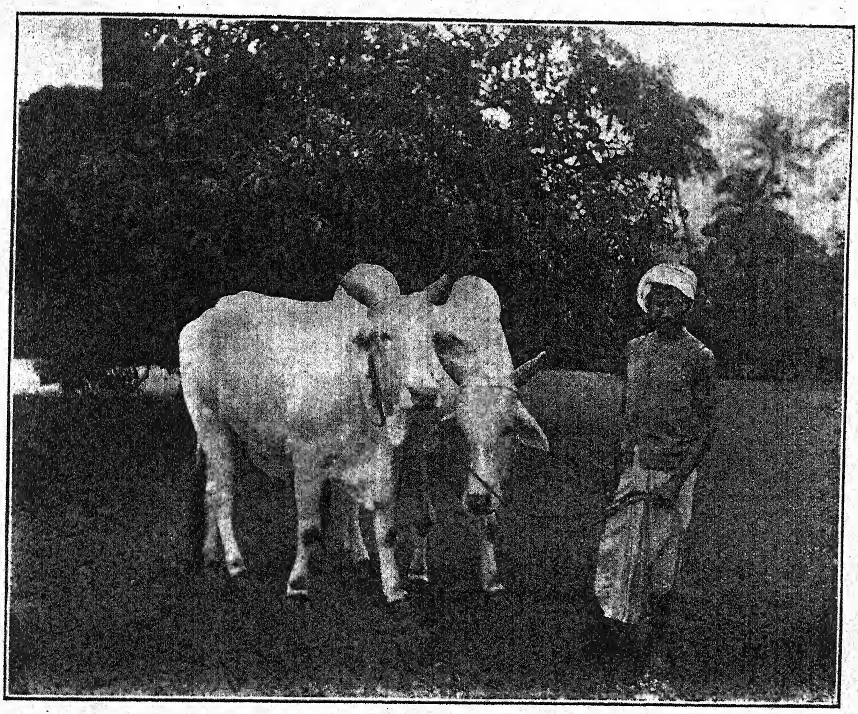
A. J. I.

way they are treated and tended as the family pets, and it is only by going into the houses of the villages that the best calves can be seen.

That there is considerable profit in the undertaking is evidenced by the high prices which the animals realize. Young bulls sell from Rs. 80 to Rs. 250. Several fine animals have been exported to South America. A good Nellore cow is worth from Rs. 80 to Rs. 150 according to the amount of milk she yields.

Ghi (clarified butter) is made in fairly large quantities and sold to merchants for export, being seldom used by the ryots, who prefer gingelly oil for cooking, and reserve the ghi for sale. A good Nellore cow gives from 11 to 14 lbs. of milk daily.

The breed is probably not so hardy as the *Mysore* or *Alumbadi*, but for slow heavy work they are unsurpassable, and they are universally employed for drawing very heavy loads in the city of Madras, frequently amounting to five tons.



The characteristics of the breed are :—

Head.—Face moderately long ; muzzle fine ; forehead broad ; eyes elliptical in shape, large and mild ; skin round the eyes is black for about half an inch ; ears long and drooping ; horns short and inclined to be stumpy ;

in cows the horns are longer than in bulls ; they are directed outwards and slightly backwards.

Neck.—Short and thick.

Hump.—Well developed.

Body.—Massive, long and deep, but some are inclined to be flat-sided. In fine specimens, the girth behind the hump is about 84 inches, height behind the hump 63 inches.

Back.—Of moderate length and invariably higher at the croup.

Quarters.—Strong with a considerable droop.

Sheath.—Pendulous ; cows have also a fold of skin in the position of the sheath.

Tail.—Long, fine and tapering.

Legs.—Strong and somewhat coarse.

Feet.—Large and somewhat soft looking.

Colour.—Black and white, and pure white ; the latter is now most esteemed, but formerly black and white was the predominating colour.

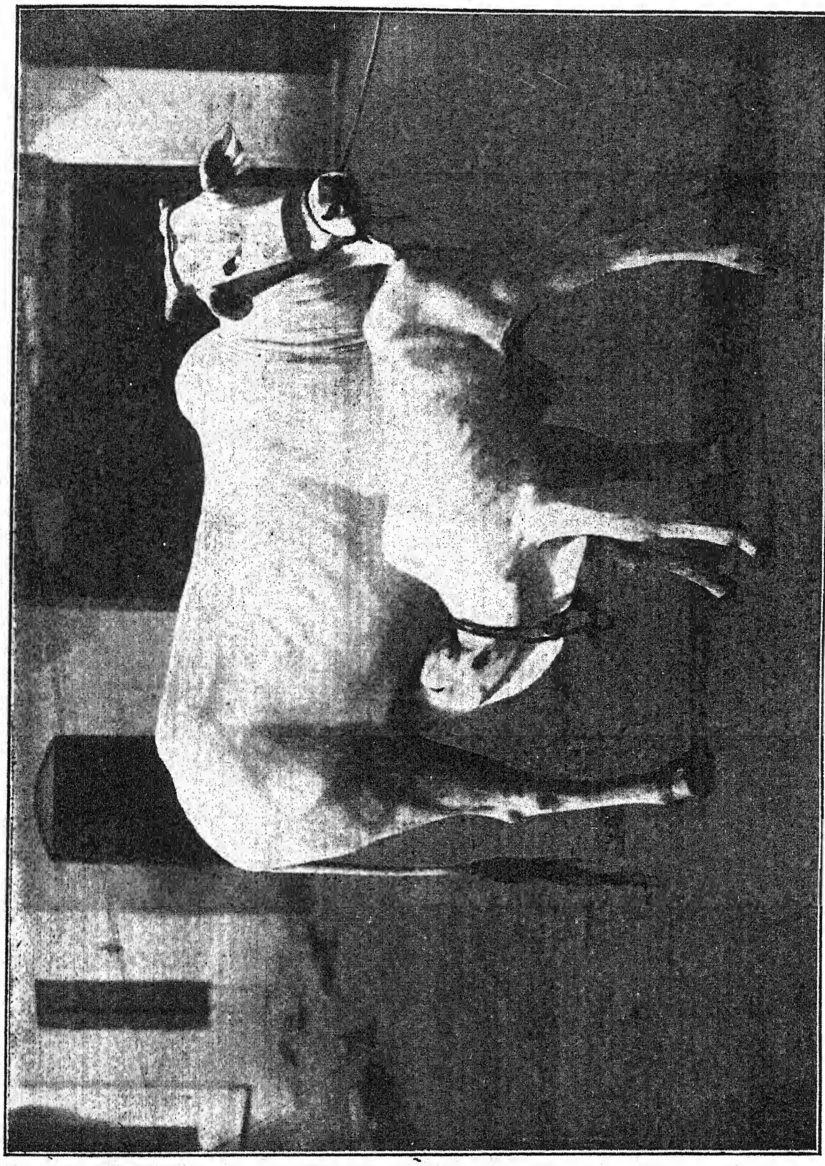
Temper.—Very docile.

The extensive pasturage obtainable in this part of the country is no doubt responsible in a great measure for the large cattle-breeding industry, which Government has always been careful to foster. Previous to 1867 a poll tax used to be levied, but in that year this was abolished in Nellore, and a principle was laid down for the future that, out of the waste of each village, an area equal to 30 per cent of the area occupied by cultivation should in future be reserved for common grazing, to be equally enjoyed by all villagers free of charge ; the surplus waste, if sufficient in extent to make it worth while to adopt the system, may be leased out for one or two years at a time to the highest bidder.

In order further to develop and encourage the breeding of good stock, an annual cattle show was established so far back as 1858, and continued uninterruptedly until 1871. During these twelve years a total of over Rs. 18,000 was distributed in prizes. The cattle show was resuscitated last year with most successful results, and it is doubtful whether such a large collection of bulls and cows of one breed have been brought together before in India. There were exhibited :—

Brahmini bulls	45
Bulls	120
Bull calves	83
Bullocks, single	22
Bullocks, pairs	31
Cows	166
Carried over ...	467

PLATE XVIII.



NELLORE COW AND CALF.

A. J. I.

Brought forward	467
Heifers	132
Buffaloes, bulls	1
„ bullocks	9
„ cows	6
Rams	38
Ewes	3
Goats, he	11
„ she	3
	670

The heifers and young bulls were an exceedingly good lot, and it is most sincerely to be hoped that, with the encouragement held out by the Madras Government, the show will be held annually and equally well represented.

Great care is taken in the selection of the village bull, and the collection of *Brahmini* bulls brought into the show at Ongole consisted of forty-five handsome upstanding animals in splendid condition. Almost every village has one or two so-called Brahmini bulls, which are common property, having been presented by the relations of a deceased villager as a memorial, or by some wealthy ryot, or having been purchased by public subscription. Such animals are always branded with a sacred mark.

Like all agricultural classes the ryots of the East Coast are very superstitious. They are usually very unwilling to exhibit a favourite cow owing to the influence of the Evil Eye (*Drishti*). A bullock whose tail has the root of the tuft of the hair situated above the hock is said to have *Eru-val* and to bring ill luck. This is not objectionable in the cow. A bullock having white hair, skin, horn and hoofs is considered of weak constitution and not to be purchased. A black bullock is generally considered a rogue; if not a rogue, he is considered of great value. The saying is :—" A black bullock is but the fourth of a bull, but if he is guileless he is a bullock and a quarter." A bullock with numerous small spots over the body "like a deer" is considered very lucky.

The form of the horns is supposed to indicate many things and receives as many names. For instance, *Madakkambu* means horns bent backwards, and is considered an excellent sign in a cow. There is an old saying :— "Let any man, who does not know how to select a cow, purchase one with horns bent backwards." Straight horns are liked. Horns pointed forwards—*Kopadi*—indicate spirit. Irregular, twisted horns—*Churuttai*—are not objected to. Those which appear hollow and have light coloured patches—*Kalikumbu*—are considered very disastrous. Horns with white tops—*Punkumbu*—are

also bad. If a cow at the time of purchase voids urine, it is considered a very good omen, but if she passes dung it is a bad sign. The reverse is the case with the bullock.

A bullock, which fails to cut the fourth pair or corner incisors, is called *Arukatti-Madu* and is considered lucky. The saying is:—"He who purchases a bullock with only six permanent teeth (incisors) will become rich enough to purchase an elephant." A bullock which cuts only seven permanent front teeth is unlucky to its owner, and is responsible for the saying that "He who purchases such a bullock should have the preparations for his funeral made ready."

Certain observances are most scrupulously carried out by both purchaser and seller at cattle sales and, in fact, have become unwritten law resting for authority on long consent. Disregard of these details in the procedure is seriously believed to imperil the prosperity of the owner, the seller and the innocent animal. The following are the principal ones:—

(1) After the price has been fixed, the buyer hands the seller a silver coin, either a two-anna bit or a rupee as earnest-money.

(2) The balance of the money may be paid at once or at any stated time afterwards.

(3) The seller has to pay the purchaser a four-anna or eight-anna bit for what is called *Maralu labham* or *Pathi Vithamalu* (cotton seed). It is intended that this money should be used by the buyer for fodder for the animal for that day. The purchaser is always careful to go with four-anna pieces in the event of the seller not having change for a rupee.

(4) The buyer must never tie up the animal with his own rope and, therefore, a purchaser never carries one.

(5) The seller must always supply the purchaser with a new rope, and if it is not available, he gives the purchaser raw material which must be braided or twisted into a rope. The seller must never give the rope already used by the animal.

(6) The seller in company with the purchasers should for a short distance lead the animal himself with the fresh rope and then transfer the rope to the hands of the purchaser who then takes the animal home. This settles the sale contract and is never disputed. The conditions of sale are never reduced to writing.

MINERAL FERTILIZERS IN INDIA.

By F. G. SLY, I.C.S.,

Offg. Inspector-General of Agriculture.

In connection with the possible introduction of a sulphuric acid industry into India, it is interesting to consider the scope for the use of mineral fertilizers in Indian agriculture. The information available upon this subject is summarized in the following note.

Phosphatic manures, mostly in the form of crushed bones and superphosphates, have been under trial for several years at some Government Experiment Stations. The results of sixteen years' trials at Cawnpore give the following average yields in lbs. per acre :—

	Maize.	Wheat.
	lbs.	lbs.
Unmanured	760	1,193
Saltpetre and bone-dust	1,280	1,697
Saltpetre and superphosphate	1,194	1,718

The results are discussed in detail in North-West Provinces' Bulletin No. 9 of 1900.

At the Nagpur Farm the average results have been as follows :—

	Irrigated wheat (11 years).	Unirrigated wheat. (17 years).
	lbs.	lbs.
Unmanured	413	470
Bone-dust	572	590
Saltpetre and bone-dust	872	791

Crushed bones have thus produced only a small increase of yield. At the Dumraon Farm, the use of bone-meal has increased the yield of wheat from lbs. 423 to 720 (average of seven years) and of paddy from lbs. 946 to 1,412 (average of four years).

The best results have been obtained at the Burdwan Farm, where the average of 14 years' experiments on paddy is as follows : —

	lbs.
No manure (14 years)	1,549
Bone-meal, 3 maunds (ten years)	3,663
Do. 6 maunds do.	3,962
Do. 9 maunds (four years)	3,033
Bone-meal, 3 maunds and saltpetre 30 seers (10 years)	4,393
Do., 4½ maunds and saltpetre 1½ maund (four years) ...	2,860

The results obtained on the farm have thus been exceptionally good. The use of bone-meal (3 maunds) and saltpetre (30 seers) has given an annual profit of Rs. 86 an acre in excess of an unmanured plot. This result is corroborated by other experiments, which show that the alluvial soil of the lower Ganges valley responds readily to phosphatic manures, particularly if applied in conjunction with organic manures. This manure can, therefore, be strongly recommended to the rice cultivators of Bengal, who should also practise green-soiling in order to get its full results. The bone-meal should be spread evenly over the field and thoroughly worked into the soil at the first and second ploughings. The saltpetre should be given as a top-dressing, when the seedlings are thoroughly established after transplantation ; in order to secure an even distribution, the saltpetre should be mixed with four times the quantity of powdered earth, and applied in two dressings with an interval of about a fortnight between each.

At the Manjri (Poona) Farm, bone-meal and superphosphate were employed in a series of manurial experiments on sugarcane, but they proved distinctly less useful than the organic manures employed (see Agricultural Ledger No. 8 of 1898).

The general result of these experiments has then been that bone phosphate has not given any large increased yields of cereals except in the Ganges alluvium of Lower Bengal. This corroborates to some extent the results of soil analyses, which show that the available phosphoric acid is not generally deficient in Indian soils except in Behar and Assam. And in this connection it may be added that superphosphate is largely used for root crops in England, which are not generally grown in India. It seems improbable that there is any immediate prospect that superphosphate at its present price will come into general use as a manure under existing agricultural conditions. In most parts of India the soil responds more readily to nitrogenous manures. The enormous export of bones (nearly 100,000 tons a year) means, however, a very large drain on the soil, which must in time require replacement, as it is not at present counterbalanced by the use of phosphatic deposits or by imports. It would, therefore, seem that in time the nitrogenous manures will

require to be supplemented by phosphates. The establishment of a sulphuric acid industry would alter existing conditions in favour of the use of phosphatic manures by the decrease in price that would result. Phosphates occur in the form of apatite as a by-product of the mica mines of Chota Nagpur, but the output is too small to be of any importance. This phosphate has been tried on a small scale with poor results. Phosphatic nodules occur in large quantities at or near the surface in the Trichinopoly district of Madras. These deposits were investigated by Dr. Warth in 1892, and an analysis by Dr. Voelcker shows that the amount of phosphate of lime is fairly high, comparing favourably with Carolina and English Coprolites, but that it is not well suited for the manufacture of superphosphate, as the quantities of carbonate of lime, iron and alumina are high, involving waste of sulphuric acid. It would thus probably pay neither to export nor to manufacture. It might be used as a slow acting fertilizer in a crushed state, but the freight charges by road are very heavy. It is already worked on a small scale to provide manure for coffee estates. The phosphate of lime found in the Christmas Islands, which is shipped largely to Japan, Australia and Europe for use by artificial fertilizer manufacturers, can be landed in bulk at Calcutta at about £2-10-0 per ton, but in its raw state it could hardly compete with bones at their present prices, making allowance for the nitrogen in the bones. Christmas Island phosphate might, however, be less costly than any indigenous material if a sulphuric acid industry could be established. The analysis of these materials is compared in the following table :—

	Apatite Hazaribagh mica mines (*a*).	Trichinopoly phosphate (*a*).	Christmas Island phosphate (*b*).
Moisture	0·37	1·62	0·74
Organic matter	...	2·71	2·80
Lime	36·42	37·22	...
Iron and alumina	1·89	11·90	2·01
Alkalis, etc.	3·00	7·76	...
Phosphoric acid	28·39	22·83	38·89
Carbonic acid	0·03	5·56	1·95
Silica	29·90	10·40	0·10
Calcium phosphate ...	61·98	49·84	84·90
„ carbonate ...	...	12·62	4·43

(*a*) Analysis made by Dr. Leather, Imperial Agricultural Chemist.
(*b*) Analysis supplied by the Director, Geological Survey of India.

I may mention some other mineral fertilizers. Gypsum is found in large quantities in the salt range of Northern India and is locally obtainable in smaller quantity at several places. It deserves special notice because it is an antidote to certain classes of saline soils (*usar* or *reh*), but the cost of

reclamation with gypsum is more than the value of the land owing to the heavy freight charges by road and rail. Nitrate of soda has lately been tried at several experiment stations, but the results are not definite.

I have omitted to notice sulphate of ammonia because the trials of this chemical have been very few. Experiments upon tea with this manure were made by Dr. Mann, but did not give successful results. It is also improbable, owing to its chemical action, that it would suit the ferruginous soils of the Mysore plateau. It is, however, used in enormous quantities for sugarcane cultivation in Java and Mauritius, both of which countries are importing into India an increasing amount of sugar, and it deserves a careful trial by sugarcane growers in India. A plant for the manufacture of ammonium sulphate has been introduced by Messrs. Waldie & Co., Calcutta. Arrangements are also already well advanced for the erection of by-product recovery ovens in coke-making, whilst with the establishment of the Tata iron and steel manufacturing concern, the output of ammonium sulphate will be large. Arrangements are also being made for prospecting the copper sulphide deposits of Chota Nagpur, and if they prove as valuable as is asserted by some authorities, it is probable that a large chemical and metallurgical industry may be started, the by-products of which will include sulphuric acid and ammonium sulphate. It is naturally to the interests of India that these should be ultilized as far as possible in the country rather than exported, and the agricultural departments should make experiments to test their utility in cultivation, particularly that of sugarcane.

The use of artificial fertilizers seems to be coming nearer within the scope of Indian Agriculture, and the establishment of a sulphuric acid industry might have important results. It is the duty of the Department of Agriculture to anticipate such a movement by a careful trial of fertilizers at Government Experiment Stations. A series of experiments upon cotton with various manures, including superphosphate and sulphate of ammonia, have been started at several Government Farms, and in time these trials should be extended, more particularly to sugarcane and other valuable irrigated crops. If such fertilizers ever come into general use, the question of guarantee of quality will become of importance.

NOTES.

Agave Fibre in Assam.—As many inquiries are received about the prospects of sisal and other agave fibres in India, it may be of interest to record the impressions derived from a visit to the plantation of the Dauracherra Fibre Company, Sylhet, Assam. The best account of the prospects of establishing an agave fibre industry in Assam is given in Mann and Hunter's book "Sisal-Hemp Culture in the Indian Tea Districts" (Thacker, Spink & Co.), but this note may supplement the information therein given by some facts derived from later practical experience.

The Dauracherra concern is the largest fibre company in Assam, about 1,000 acres having been planted out with agaves. There are other plantations in Assam, the total area under agaves being about 3,500 to 4,000 acres. At Dauracherra, most of the land is devoted to *sisal*. There is also some Mauritius hemp (*Fourcroya gigantea*) which grows equally well but is not so popular, because there is no suitable machine for its treatment on a large commercial scale. The machine at work at the factory is the Torruella, which has given complete satisfaction in the treatment of sisal, but the strain is too great for the weaker fibre of Mauritius hemp. All other varieties of agave have been discarded after trial as being in no respect equal to sisal. It is estimated that one Torruella machine (price £600) will treat the produce of 600 to 800 acres of sisal. Some portions of the plantation are now commencing to come into full yield, and it is stated that the outturn may be placed at half a ton of dry fibre per acre at a low estimate. The green leaves yield about 4 per cent of dry fibre, of which three parts are good straight fibre equal to sisal from other parts of the world, whilst one part is made up of short uneven fibre ("tow") fetching about one-third of the price of the former.

Dauracherra is situated in the valley of the Surma river, some 60 feet above sea-level with an average rainfall of about 80 inches. The climate is fairly equable with no intense cold or heat, whilst showers are received off and on almost every month. For instance in the so-called dry season, rain

usually falls about Christmas, and there are generally good showers from March onwards until the regular monsoon. The country is thus exceptionally favoured for the continuous growth of vegetation, so that the sisal has no prolonged period of rest.

The growth of the plants was certainly good and fairly even. It is planted out on the tops and sides of a succession of small hills (called *teelas*), but although the country is thus considerably broken up, the soil seems a fairly good loam even on the slopes and tops of these hills. The soil is thus nothing like as poor as the bare laterite plains of the Deccan. It is virgin land, which was under a dense growth of mixed forest before it was reclaimed. The plants are generally more advanced in the richer soil of the intervening valleys, but the greatest care is required to keep these thoroughly drained. Any water-logging is fatal to sisal. The percentage of fibre is somewhat smaller in the larger plants in the valleys, but this may be compensated for by the quicker growth. Clay soils are unsuitable, an open loam being the best. Shade is bad for the plants, resulting in long thin leaves, which do not give such good fibre.

The plantations have as a rule a good even stand of plants, without the inequality which is so marked a feature of the Hindupur Fibre Station of the Madras Department of Agriculture. This evenness of stand is, perhaps, largely due to the considerable care exercised in setting out the plantation. The young plants should be at least one foot high, and even larger if possible. All weakly plants are discarded. Suckers are preferred to plants raised from bulbils in the nursery. Pits are dug about 1 foot deep and $1\frac{1}{2}$ foot square. In the earlier years the plants were set out too far apart; the most economical distance is now said to be 9 feet by $4\frac{1}{2}$ feet by $4\frac{1}{2}$ feet, *i.e.*, two rows $4\frac{1}{2}$ feet apart with $4\frac{1}{2}$ feet between plants in the row, and then a space of 9 feet for convenience in harvesting the leaves. Mann and Hunter's book gives perhaps a somewhat exaggerated idea of the amount of cultivation. The land is not hoed nor weeded in the ordinary sense of these terms, not even close round the plants, but the whole area is kept clear of rank tall grass and scrub by cutting it down as often as is necessary.

Crickets do a certain amount of damage by cutting off clean the hearts of young growing plants; no effectual remedy has yet been discovered. There are also two or three fungus diseases which attack the leaves, but these have not as yet done very much real harm. It is not believed that any of them will become a serious pest. An account of these fungus diseases is given in a subsequent note at page 261 of this Journal.

There is no definite information as to the age at which sisal will flower under plantation treatment. Some untreated plants have poled at ages varying

from 8 to 12 years, but it is believed that the life will be longer of plants, the mature leaves of which are regularly cut. The plantations yield about two heavy or three light cuttings a year, the latter being of course a preferable method of harvesting where labour is cheap. The waste vegetable matter from the factory is not at present utilized.

Although most of the plantations are as yet too young to yield definite results, the Company seems quite satisfied with its prospects. Whether equally promising preliminary prospects could be secured in other parts of India with less favourable conditions of soil, climate and rainfall, is a matter of more doubt.—(F.G.S.)

*
* *

Co-operative Experiments.—In Bulletin No. 3, Vol. VI, of the West Indies Department of Agriculture, an interesting account is given of a set of manurial experiments on cotton made by planters on their own estates, under the guidance of the Department of Agriculture. The value of such co-operative experiments should be very real in India, provided that too much is not attempted at once and that the issues under consideration are limited. In this case the crop experimented on was cotton, and a list of thirty-eight plots was drawn up. These were 1-40 acre in size, and were divided by rows of pigeon peas (arhar or tuer, *Cajanus indicus*), the whole series taking up about one and-a-half acre in all. Twelve estates succeeded in carrying their experiments to a successful conclusion, and the results are published in detail, with additional figures giving the average yield of all the stations in pounds per plot and per acre, and the excess or otherwise per acre, due to the application of manures.

The subject of co-operative experiments is no new one. As far back as 1886, the Bath and West of England Society instituted organized co-operative manurial experiments of this kind. It is to be noted that the object of these experiments was not so much the discovery of any new manurial principles, but the demonstration and confirmation of lessons already deduced from observations made at such stations as Rothamsted and Woburn. It seems likely that there are few other methods so efficacious in educating the farmer or planter to use his own judgment in the application of manures, and in stimulating him to carry out simple manurial tests on his own land for his own benefit. The general results obtained from such co-operative schemes will clearly indicate the general nature of the manure suitable for any crop, whether nitrogenous, phosphatic, potassic or combined, while a careful study of the variations obtained at different stations, especially if these stations are on estates with which he is familiar, cannot fail to inculcate the importance of varying the manure to suit the land or the system of cropping employed.

This last factor is one of real importance, and in drawing any results from figures obtained in an experiment, the previous crop and its treatment should always be borne in mind.

Another point to which attention should be paid is the duplication of plots. It would no doubt be perfectly easy for many landowners to choose a site for experiments which they knew from past experience to be uniform, and from which results perfectly satisfactory to themselves could be drawn, but from a scientific point of view, the results are much more convincing and carry more weight with people who have had no opportunity of seeing the experiment, if some or all of the plots are checked by this method.

With regard to size, the plots should not be smaller than 1-20 of an acre, and might with advantage be larger. Care should be taken to keep the plots quite separate, and in the case of a crop like sugarcane it might be well to manure say twelve rows, but to cut and weigh only ten, disregarding the outside rows as being influenced by neighbouring plots. The manures chosen should be such that one or more definite issues are raised which may be answered directly by the results obtained. Thus the relative value of nitrate of soda and sulphate of ammonia for a certain crop could easily be decided by laying out a four-plot test as follows :—

No manure.	Complete manure, containing sulphate of ammonia.	No manure.	Complete manure, containing nitrate of soda.

and a definite answer to this enquiry would be obtained. The quantity of a given manure which it is profitable to apply might be discovered by manuring a large plot with the other constituents of a complete manure, and then dividing it into strips on which the quantity of the manure under consideration might be varied.

We recognize that in many cases Indian conditions are not favourable to tests of this character : the small size of holdings and the character of the cultivators in some cases prevent the adoption of such a system ; but where conditions are favourable, provincial departments should be able to draw up simple schemes of manurial tests on selected crops, which should furnish valuable results under a system of careful supervision by the agricultural staff.—(R. C. W.)

* * *

Jute Experiment.—The Bengal Department of Agriculture has issued a leaflet giving the results of the jute experiments conducted last year at the Burdwan Government Farm. These include trials with different manures, cutting the crop at different stages of growth, testing numerous varieties,

spacing the plants at varying intervals, sowing broadcast or in drills, and sowing seed obtained from an ordinary crop and that obtained from a crop grown much more thinly for seed purposes only. The experiments have only been in progress for a couple of years, so that reliable results cannot yet be expected; but so far as they have gone, they mostly confirm the practices ordinarily followed by jute cultivators. A mature crop gave a larger outturn of fibre than a crop cut at an earlier stage, but the quality of the fibre is not given. Cowdung gave better results than all the other manures, which included castor-cake, bone meal and saltpetre. This confirms the general conclusion obtained from experiments with other crops that the Ganges alluvial soil is deficient in organic matter. We should like to see a plot added in order to test the effect of the application of phosphates in combination with organic matter, which has been very successful with other crops. Sowing in lines four inches apart gave better results than sowing at wider distances and than broadcasting. The testing of varieties has not yet given definite results.—(F. G. S.).

*
* *

EXTENSION OF JUTE CULTIVATION.—The first experimental trials of jute in the Godavari delta of Madras and in the Central Provinces have not been successful. In both cases, the failure seems to be mainly due to the same cause—the waterlogging of the plots in the early stages of growth. The young jute plants were damaged by the plots being kept under water. Whilst jute will tolerate prolonged flooding in the later stages of growth, it is very sensitive to an excess of water in its young stages even in Bengal. This error will be avoided in the present year's trials. Trials on a commercial scale will also be made by a Madras firm at Rajahmundry in the Godavari district. The Eastern Bengal and Assam Department of Agriculture have, further, arranged a scheme for the extension of jute cultivation to the upper districts of Assam. Mr. Finlow, B.Sc., Jute Specialist, has completed a tour in the Bombay and Madras Presidencies and the Central Provinces, in order to investigate the possibilities of the extension of jute cultivation in those parts. His report, which will shortly be published, should give much valuable information about this important subject. There is little doubt that the present demand for jute is in excess of the supply, and several countries are now endeavouring to introduce the crop, notably Java and West Africa. The Inspector-General of Agriculture has recently supplied 5,000 lbs. of seed to the Colonial Office for trial in West Africa. If India is to retain her monopoly of the world's supply of jute, it seems clear that there must be a considerable extension of cultivation.—(F. G. S.)

SELECTION AND DISINFECTION OF SUGARCANE CUTTINGS.—Some useful instructions are given in Bulletin No. 1 of the Hawaian Sugar Planters' Experiment Station regarding the selection and treatment of sugarcane sets used for planting. There is probably no part in the whole operation of the cultivation of sugarcane, where a little time can be so profitably spent as in the inspection and disinfection of the cuttings to be employed for seed. The maxim, "the best is none too good for seed" is a true one, and though on many estates the loss from disease may be small, and the extra expense of careful supervision not fully justified, yet our knowledge of many of the diseases of cane is so slight, and their attacks are often so insidious, that the omission of such precautions is always a risky proceeding.

Firstly, then, every cane planter should become thoroughly familiar with the appearance of healthy specimens of the variety to be planted ; every cane that shows any departure from this should be unhesitatingly condemned. There is no doubt that this rule will in many cases act so as to exclude the greater number of the cuttings : but even if this is the case, the inclusion of any such canes in the seed is fraught with the danger of propagating the disease. Special attention should also be paid to the area from which the seed canes are cut ; this should be from the healthiest field on the estate and should be carefully inspected previous to harvesting, care being taken to remove all patches which are stunted or poorer in any way than the surrounding crop.

There is the greatest need for the exercise of care in this respect in Behar, since it has been established that one of the chief modes of propagation of the disease known as red rot or red smut (the so-called "rind disease" of the West Indies) is by the planting of sets already containing the fungus. When the parasite is present in the sets, its existence is generally betrayed by a reddening of the tissues which can easily be seen at the cut ends. Every set showing such reddening should be discarded. Some twenty-five cane varieties from all parts of India have been grown at Pusa for the last two years and treated in this manner, with the result that red rot has practically disappeared from all but two. It is not suggested that this is the only method of propagating the disease, but in Behar it is by far the most important, and selection of cuttings should become established as a routine practice in sugar planting.

Having thus taken all precautions to obtain healthy cuttings attention must be given to the methods available to prevent their infection while in the ground. The cane is provided with a hard cuticle which is an effectual barrier against the entrance of fungus, but the cut ends expose it to a risk of infection. To minimise this, the cut ends should be as clean as possible :

the knife used should be sharp, and the cut should be given with a slicing motion as thereby the shattering of the cut ends is avoided. Care should be taken to give each eye as much cane as possible upon which to draw for its nourishment in its early growth.

The canes may now be disinfected with various mixtures of copper, such as Bordeaux Mixture or pure copper sulphate solution ; this will effectually prevent the growth of any fungus spore which may come in contact with the cut end. Here again we see the importance of having a clean-cut end ; for if a shattered end is dipped in the liquid, air bubbles are enclosed in the fractures, and portions of the surface are left untreated and thus offer an open door to the attacks of fungus.

It will thus be seen that the production of good seed is the result of the observance of a number of details each in themselves insignificant. The net result, however, may often prove to be the difference in value between a healthy and a diseased crop of cane.—(R. C. W.)

* * *

Cotton Cultivation in Burma.—A report on cotton cultivation in Burma, recently published by the Department of Agriculture, discusses in considerable detail the possibilities of the extension and improvement of cotton in that country. It has been urged by some authorities in England that Upper Burma is a most promising country for the growth of long staple cotton, but this report does not hold out much prospects of success. Cotton is already a well-known crop in the dry zone of Upper Burma, but the area averages only some 150,000 acres and shows no tendency to increase. The principal variety is similar to that grown in Bengal, from which country it is believed to originate, and produces only coarse lint about equal to "Fine Bengals." The best of the crop is carried by road across the Chinese border, but the bulk of the exports go by sea to Japan, China and India. As a rule, it is only the poor land that is put down to cotton, for it is not such a paying crop as many others. The rainfall is notoriously precarious ; in some years the cotton is damaged by heavy falls, whilst in others it suffers from drought. In the principal cotton-growing tract around Myingyan, late rains often spoil the crop just before it is ready for picking, whilst in Prome cold cloudy weather about Christmas time injures the flowers. The crop receives little attention, the methods of cultivation being very primitive ; the seed is scattered broadcast, thinning and weeding are done very sparingly, so that good yields can hardly be expected. The short supply of labour and the consequent high wages are a great handicap against cotton, which requires a good deal of cheap labour. The want of good communications also prevents any considerable cultivation of such a bulky

crop, which demands cheap means of transport. For these reasons, the Burma Department of Agriculture rightly concludes that under existing conditions there is little prospect of the extension of cotton cultivation in Burma.

The Government of India consider, however, that the conditions would be considerably altered if the quality of the lint could be largely improved and the yield increased. With larger profits from cotton cultivation, many of the difficulties now experienced would disappear. So far as climatic conditions are concerned, there seems *primâ facie* nothing to prevent the growth of finer varieties. The possibilities of growing Egyptian and other long-staple cottons under irrigation should not be neglected, for such a crop, if successful, should be able to compete with rice. There are thus many matters which require to be settled by experimental work by the Department of Agriculture, before it can be definitely stated that fine staple cotton cannot be profitably grown in Upper Burma.

The report contains some information concerning the so-called "Pernambuco" variety of cotton, which is a perennial tree-cotton with kidney seed, producing fine silky lint of good quality. Owing to some high valuations of this cotton, it has attracted more public notice than it seems to deserve. It is not at present grown as a field crop, a few scattered plants being found in some house-gardens of villages. There seems to be nothing to distinguish this variety from the similar plants found under the same conditions in many parts of India, the superiority of the lint being probably due to the favourable climatic conditions along the sea-coast in Tenasserim. Experiment has yet to show whether it can be successfully grown as a field crop.—(F. G. S.)

***

THE EFFECT OF AMMONIA SALTS IN CERTAIN EXPERIMENTS IN ENGLAND.—One of the most famous agricultural experiment stations is that situated on the Duke of Bedford's Estate at Woburn in England, which is controlled by the Royal Agricultural Society of England. Among the numerous experiments conducted there, is one in which wheat on one set of plots, and barley on another, are cultivated every year. For each crop there are eleven principal plots (some of which are subdivided), and each of these plots is treated and manured in one or other special manner every year. In the present instance we are concerned with those plots only on which ammonia salts have been applied. The experiment has been in progress for thirty years, and until upwards of twenty years had elapsed, nothing unusual was noticeable in regard to either of the crops. About this period, however, the barley commenced to fail on the plots manured with ammonia salts, and the decline

during the succeeding years was very rapid, culminating in absolute failure. The wheat has been affected in a less degree. Obviously in such a case, the question arises whether this result is attributable to the fertilizer or to some special feature of the soil or to both combined. The ammonia salts employed have consisted of equal parts of the chloride and sulphate, containing 50 lbs. or 100 lbs. of ammonia per acre per annum on different plots. It may be stated at once that, although the chloride (muriate) is not commonly used for this purpose, the sulphate finds a very wide and indeed general application in Europe and America, and this fact alone must negative any suggestion that sulphate of ammonia is of doubtful utility. Another useful piece of evidence in this connection is the fact that these two salts have been employed in a precisely similar manner for wheat and barley at the Rothamsted Experiment Station for over sixty years ; they have been added to the same plots of land year after year over this long period, and here both the wheat and barley continue to grow in a normal manner. The evidence, therefore, goes to show that the effects which have been experienced at Woburn must not be attributed simply to an evil effect of the ammonia salts.

As a matter of fact one suggestion occurs almost immediately to those who study the chemistry of soils and manures. It is well known that the ammonia of these salts is changed in the soil through bacterial agency into an altogether different substance, namely, nitric acid. Such a substance, however, will not remain a free acid if it is in contact with any of the opposite class of substances, namely bases, so that if the latter are present in the soil in sufficient amount, the nitric acid enters into a state of combination with one or other of these bases and forms a salt, one or other of the nitrates in fact.

A second point to notice is the fact that so soon as the ammonia suffers the change described, the acid—sulphuric acid and hydrochloric acid in the salts used at Woburn and Rothamsted—with which it was combined, is also set free, and, like the nitric acid, will combine with bases which may be present to form new salts. Thus there is on both hands a requirement of base year by year. The base usually most readily at hand in the soil, and indeed the one most desirable, from the agricultural point of view, is lime. The quantity involved in any one year is quite nominal. The ammonia salts employed at Woburn would occasion the neutralization of only some two or three hundred pounds of slaked lime per acre. On the other hand, soils contain generally 50 or 100 or more times this quantity. But if these salts are applied to land year by year, and if at the same time the whole quantity of lime present in the soil is only small, then the ultimate effect

will be a serious reduction of the free lime present, followed also by the natural consequence that the crops will suffer. Unlike the Rothamsted soil which contains a liberal amount of lime, the Woburn soil contains only a small quantity, and the continued application of the ammonia salts over a long series of years reduced this to a seriously small amount. The obvious preventive course is periodically to add some lime to such soils. This was pursued at Woburn. To one-half of each of the affected plots some lime, two tons per acre, was applied in 1897, and almost immediately the crops became normal. The figures (bushels of corn per acre) are so interesting that those for the last few years may be quoted.

Plot No.	MANURE.	1898	1899	1900	1901	1902	1903
	WHEAT.						
2a	Ammonia salts	27·8	19·1	12·5	·6	4·9	7·1
2b	Ammonia salts and lime ...	31·5	29·0	17·8	5·2	12·4	16·6
	BARLEY.						
2a	Ammonia salts	7·6	5·5	5·6	8·2	·8	1·3
2b	Ammonia salts and lime ...	16·5	30·3	28·9	17·1	29·6	5·6
5a	Ammonia salts and superphosphates	4·5	6·0	12·3	15·5	12·8	1·3
5b	Ditto and lime ...	35·3	40·0	33·7	23·9	51·4	11·5

Lime was applied in 1897 to the *b* half plots, and a glance at the outturns shows how effective this single dose has been. It has, indeed, proved a perfect cure for the evil. A cautionary word must be added to avoid misconception. Whilst liming the land is a usual way of supplying sulphate of ammonia with the base it requires, it would not answer the purpose at all to mix the two substances together previous to being used on the land, for the effect of this would be the liberation of the ammonia into the atmosphere, whereas we require it in the soil. The lime, if it is required at all, should be put on the land at an entirely different time from that when the sulphate of ammonia is used. Lime is best applied when land is being rough ploughed after a crop has been harvested, whereas sulphate of ammonia should be put into the soil either at the time of sowing or after the crop has grown two or three inches high.—(J. W. L.)

*
* *

EXPERIMENTS IN THE CULTIVATION OF DATES.—Arrangements have been made for starting experiments in the cultivation of edible dates (*Phœnix dactylifera*) in the province of Sindh. There have been in the past many experiments for the introduction of date cultivation in several parts of India, but these have almost invariably ended in failure. An examination of the reports of the experiments shows that these failures have generally

resulted either from the trials being made in localities where the climate is clearly unsuitable or from incorrect methods of cultivation. There is reason to hope that success may be achieved in Sindh. The climate should suit the edible date. Sindh is situated on the isotherm characteristic of this plant; it is practically a rainless tract and experiences the intense dry heat in which the date naturally flourishes. The canals can supply ample water for irrigation, and the drainage is good. Above all, inferior varieties of date are already successfully grown. Arrangements have been made for obtaining offsets of all the best varieties of date from Egypt, Morocco, Algeria, Tunis and Persia, which will be tried experimentally in Sindh under the supervision of Mr. Fletcher, B.Sc., Deputy Director of Agriculture, Bombay, who has practical experience of the Egyptian methods of date cultivation. There are thus reasons to hope that this trial will be more successful than those made in the past.—(F. G. S.)

*
* *

New Experiment Stations in Madras.—The Madras Department of Agriculture has arranged to start a new experiment station at Attur in the Chingleput district. The site selected was originally acquired as a pumping station to determine the quantity of water which could be obtained from a well sunk on the margin of a sandy river like the Palur and to ascertain the best motor and pump for lifting the water. The supply of water in the well sunk on the river bank has been found to be unsatisfactory for irrigation on a large scale. It has now been decided to devote the land to the thorough trial of perennial and exotic cottons under irrigation and to the growth of fodder crops, the want of which is a noteworthy agricultural defect in the Chingleput district. Arrangements have also been made to start another new experiment station at Nandyal in the Kurnool district. This will mainly be devoted to the study of the varieties of cotton known as 'Northerns' and their improvement by selection and cross-breeding. It is also proposed to study the sorghum crop of the Nandyal valley, and possibly to introduce new varieties of indigo as a leguminous crop for rotation purposes.—(F. G. S.)

*
* *

Formaline Treatment of Oat Smut.—For the prevention of oat smut, commercial formaline, which is a solution of about forty per cent. strength of formaldehyde, has of recent years been found remarkably useful, possessing some advantages over the more commonly employed copper sulphate. Some experiments to test its effect were carried out last year at Dehra Dun, where the disease is severe and causes an appreciable loss

annually to cultivators, the locality being one of the few parts of the United Provinces where oats are largely grown.

The extent of the disease was estimated on a number of fields, both by calculating the actual number of ears smutted per acre from actual counts in measured areas, and also by ascertaining the percentage of smutted to healthy ears. It was found that about 180,000 ears per acre were lost on an average in the fields examined, and that the percentage of smutted ears to healthy averaged ten and-a-half.

Four plots of about one-tenth of an acre each were sown. In one of these the seed was untreated. A second was sown with seed which had been soaked for four hours in formaline of a strength of one ounce to two and-a-half gallons of water (or one-tenth per cent. formaldehyde). A third received seed soaked in one-half per cent. copper sulphate for twenty-four hours, and a fourth was similarly treated with one per cent copper sulphate.

The germination of the plot treated with formaline was the best, both the copper treatments resulting in injury in this respect. The results as regards the degree of smut which appeared as the crop ripened were as follows :—

	Plot I untreated.	Plot II Formaline 1 oz. to $2\frac{1}{2}$ gals. water.	Plot III $\frac{1}{2}$% copper sulphate.	Plot IV 1% copper sulphate.
Number of smutted ears estimated to the acre	172,495	1,092	2,115	1,069

The formaline treatment was the most successful and gave a good crop, slightly better than the untreated plot. The crop on Plot III was only moderate, while Plot IV was distinctly poor. This was due to the long soaking in copper sulphate, which injured germination. Even with this long treatment the amount of smut in Plot III was nearly twice as much as in the formaline plot, while Plot IV had only slightly less smut than Plot II, and had it contained the same number of plants would no doubt have had proportionally more smut.

As regards convenience of treatment, formaline is the best, for it need only be poured into water and stirred with a stick when it is immediately ready for use. Ten gallons of the solution, requiring four ounces of formaline, is sufficient to treat enough seed for one acre. With copper sulphate, on the other hand, the "blue-stone" must be dissolved in the water, which takes some time. Formaline may be used in any sort of vessel, whereas copper sulphate must not be placed in an iron one.

The formaline treatment is more expensive, costing on a small scale about four annas an acre. On a large scale the cost can be much reduced, for the same solution may be used to treat several batches of seed. The profit resulting from the treatment is so considerable where smut is severe that the slightly greater cost of formaline as compared with copper sulphate makes very little difference. In Dehra Dun the extra yield from the formaline plot was about one seer in ten.—(E. J. B.)

*
* *

A Paddy Disease in the United States.—Fungus diseases of paddy are not numerous in any country and are rare in India. Green smut (*Ustilago virens*) in Tinnevelly, and a leaf spot (*Helminthosporium sp.*) in Bengal have been from time to time reported, but appear to be of no great importance. A disease locally known as *chatra* or *dakhina* sometimes does a considerable amount of damage in several districts of Bengal. Its cause is unknown, but it is allied to the destructive "brusone" of Italy. In a recent number of the *Tropical Agriculturist*, mention is made of a serious rice disease which has broken out in the rice-growing regions of South Carolina in the United States. The variety of rice chiefly grown there is that known as "Carolina Golden," which commands a fancy price in the American markets. In letters quoted from Mr. David G. Fairchild, Agricultural Explorer to the United States Department of Agriculture, some particulars are given of this fungus disease. Its cause is not yet definitely ascertained, but prompt steps are being taken to introduce similar rices from other tracts and from abroad, in the hope that some may prove resistant to infection. It requires little imagination to picture the devastation which would result from the appearance, in the densely-populated rice-growing areas of India, of a disease, which in Mr. Fairchild's words "has threatened the annihilation of the rice industry of the Carolinas."—(E. J. B.)

*
* *

Red Rot of Sugarcane.—This disease was exceptionally prevalent in Behar last year in estates which are still growing susceptible varieties. This appears to have been due to the unfavourable season experienced. It is stated that the severe cold of February, 1905, led to weak germination of the tops cut from those fields which had been kept for late seed. This was followed by the floods of August and September. A moist soil, due to insufficient drainage or prolonged floods, greatly favours the growth of the fungus *Colletotrichum falcatum*, to which red rot is due, and from October on the disease became more and more marked. There is little doubt that the parasite was already present in a considerable proportion of the seed used, and the almost ideal conditions for its growth which prevailed during the

latter half of the year led to the outbreak experienced. With the possibility of such unfavourable years, it is important to see that only thoroughly reliable cane varieties are grown on a large scale. Several of the varieties now grown have shown their liability to disease, and even where one of these has been successful for some seasons on a particular estate, the danger of a large amount of disease appearing in an unfavourable season is so great that it cannot pay to continue to grow it.—(E. J. B.)

* * *

EXTENSION OF POTATO DISEASE.—The gradual extension of potato disease (*Phytophthora infestans*) to parts of the world hitherto free still continues, though more than sixty years have elapsed since the first great outbreak in Europe and North America. The disease is supposed to have spread in the first instance from Chili, the original home of the potato. For many years Australasia remained free from it. About thirteen years ago, however, a mild outbreak occurred at Auckland in New Zealand. Nothing was heard of it again until 1904-5, when an epidemic occurred which is described in the last Annual Report of the Department of Agriculture in New Zealand, and is estimated to have cost the colony over £150,000. Prompt steps have been taken by the Department to introduce spraying, and it is anticipated that a vigorous campaign will be undertaken to stamp it out. The importation of clean seed from Australia, where the disease is believed not to occur, is also recommended.—(E. J. B.)

* * *

DISEASES OF RUBBER TREES.—The Para-rubber tree (*Hevea braziliensis*) is attacked by a canker caused by a fungus of the genus *Nectria*, an account of which was published in Vol. II, No. 29 of the Circulars of the Royal Botanic Gardens in Ceylon. The same disease is reported from one of the Burma rubber plantations, and the Nectria has been discovered in the cankers. Its treatment, which requires to be carried out systematically for several years, is to cut out the cankered parts and burn them. This should be done in sunny weather and when the trees are leafless. *Castilloa elastica*, the growth of which is said to be extending in South India, is subject to a more serious disease than the canker. Fortunately, it is probably confined to a small area as yet. This is the work of a *Diplodia* fungus which invades the entire woody parts of the tree, completely killing it. The only method of treatment is to uproot and burn the trees, so as to prevent spore-formation by the fungus, and thus save adjacent trees from infection. Though a drastic method, there should be no hesitation in employing it where disease appears, for the affected trees are useless and a source of great danger to their neighbours. Rubber planters who are wideawake may

be able, by taking prompt steps on the appearance of these diseases, to stamp them out before they obtain a hold. In these, as in most other cases of disease, early attack is half the battle.—(E. J. B.)

*
* *

Sisal Hemp Disease.—A disease of cultivated Agaves, caused by the fungus *Colletotrichum Agaves*, is described by Mr. Hedgcock in the 16th Report of the Missouri Botanic Garden. The same fungus has been found in several parts of India, and the disease which it produces has been a cause of some alarm on sisal estates. In America it has not been known to attack sisal, but in India it often does so. The older leaves are first attacked, small sunken patches appearing where the fungus has entered. These turn brown and dry up in the centre, while they spread at the margin. In the dried-up parts, spores are produced in little black clumps, which blow about and infect healthy leaves. This fungus has also been found on several occasions associated with the much more serious sisal disease in which the tips of the leaves wither from just under the thorn to half their length or more. In both cases the treatment is the same. All diseased leaves should be cut and burnt as soon as the patches appear. By this method the spread of the *Colletotrichum* has been checked in the Missouri Botanic Garden.—(E. J. B.)

*
* *

Analysis of Rubber.—The Imperial Institute proposes to undertake, during the current year, the examination of samples of rubbers from India. Samples of rubber of any importance will be examined chemically and also sent to brokers for valuation. Special attention will be given to *Ficus elastica* with the object of ascertaining if the produce of the Government plantations can be improved. In order to stimulate interest in the development of rubber planting in India, it is suggested that samples of rubber obtainable from the various Indian plantations, on which Para, Ceara and Castilloa rubbers are being tried, should be sent to the Imperial Institute for examination and valuation. All samples should be sent to the Reporter on Economic Products, Indian Museum, Calcutta, for transmission to the Imperial Institute.—(F. G. S.)

*
* *

Testing of Fibres.—Arrangements have now been made in the laboratory attached to the office of the Reporter on Economic Products, Indian Museum, Calcutta, for testing the strength of samples of Indian fibres. Where a complete examination is required, samples will continue to be sent to the Imperial Institute for analysis. The Reporter on Economic Products is also interesting himself in the improved preparation of Agave

fibre and the finding of brush fibres that could be produced in India.—(F. G. S.)

*
* *

THE COMPOSITION OF RICE.—The Curator of the Industrial Section, Indian Museum, has started an investigation into the composition of the many varieties of rice grown in India. Rice grain will be subjected to chemical examination with special reference to use as material for making sizes.—(F. G. S.)

*
* *

THE GERMINATION OF JAVA INDIGO SEED.—The substitution of the old variety of indigo grown in Behar (*Ind. sumatrana*) by the new and more valuable Java variety (*Ind. arrecta*) has been attended by a serious difficulty in the poor germination capacity of its seed. This has been found due to the existence of a hard seed-coat, which does not allow of the penetration of moisture. The difficulty has been met during the past two or three years by submitting the seed to a "scarifying" process in specially constructed machines, whereby the hard coat is sufficiently deeply scratched to allow water to penetrate. This treatment has proved perfectly satisfactory, but is somewhat difficult of application, due to the mechanical adjustments necessary in the machine to produce the most efficient results.

It has recently been found that the same end can be attained more simply, with more certainty of success, and at no greater cost (having regard to the price of the scarifying machine and its uncertainty of action) by treating the seed with strong sulphuric acid. This is accomplished as follows :—The seed to be treated is placed in a large water-tight wooden vessel, and undiluted commercial sulphuric acid is poured over it and stirred in with a wooden or iron instrument until every seed is wet ; it is then left for the action to proceed for exactly half an hour. At the end of this time, a large quantity of clean cold water is rapidly poured on to the seed, which is thoroughly stirred meanwhile. The seed is then allowed to settle to the bottom of the vessel and the water poured off. A fresh supply of clean water is then added and the seed thoroughly washed and the water poured off as before. This is repeated a third time, after which the seed should be free from acid. It is then spread out in the sun to dry and is ready for sowing. The proportions of substances used for the treatment, which should be strictly adhered to, are as follows :—

Seed	... ½ maund.
Acid	... 20 seers.
Water	... 20 gallons (for each washing).

It is not recommended to treat more than ½ maund of seed at a time.

The method has the advantages that all bad, hollow seed and other, impurities float up, and may be poured off during the washing operations, and the appearance of the seed is very considerably improved. It is not advisable to keep treated seed through the rains unless it is put into sealed tins, as it is liable to deteriorate.

The method may be applicable to other "hard" seeds of which many cases are known to occur.—(C. B.)

*
* *

Soil Inoculation for Leguminous Crops.—The introduction of the cow-pea (*Vigna catiang*) into Behar as a green-manuring crop seems to have demonstrated the adaptability of the nitrogen-fixing bacteria, which form "nodules" on leguminous crops, to pass from one species of legume to another. So far as is known, the cow-pea has never before been grown on or near the soils at present bearing it; nevertheless the roots are heavily beset with nodules, and the crops obtained seem to indicate that no inoculation could improve matters. The explanation almost certainly lies in the adaptation of the nodule organism of some other leguminous crop to the cow-pea.—(C. B.)

*
* *

Rubber Experiments in Bombay.—Arrangements have been made to test some rubber-yielding plants in parts of the Bombay Presidency. These will form the subject of special study at the Bassein Botanical Garden. Two experimental plantations of about ten acres each will also be started by the Forest Department in the Kanara district with para-rubber (*Hevea braziliensis*), but the Conservator of Forests is sceptical of success owing to the climatic conditions being unlike those obtaining in countries where this tree thrives. Some promising trials of *Ficus elastica*, the rubber tree of Assam, are in progress at Belgaum.—(F. G. S.)

*
* *

Potato Cultivation.—Mr. J. G. Stewart gives some useful information on this subject in the April number of the Journal of the Board of Agriculture. In discussing the selection of potato seed for yield, he says that two kinds of small potatoes must be considered; first, the late formed tubers of strong, robust plants; and secondly, the produce of plants of low variety. He considers that quite satisfactory results can be obtained from the former, as the tubers are small simply on account of their not having had sufficient time to reach full size, but with regard to those produced from poor plants, only inferior tubers can be expected. He thinks too that

if seed from the same stock is used for a number of years in succession, there will be an ever increasing produce of inferior tubers, and that this should be avoided. Experiments show that whole tubers about the size of a hen's egg generally prove the most profitable, and that it is unwise to make good a deficiency by cutting seed-size tubers. No reduction in yield need be feared from sets obtained by cutting bigger tubers. These, however, should more appropriately be used for market purposes.

If cutting is resorted to, the sets should be planted and covered with as little delay as possible. Exposure even for a short period may reduce materially the yield from cut sets. Should it however be necessary to cut seed some days in advance, it is advisable to dip them at once into finely powdered lime. The effect of the lime is to form a 'Scab' over the wet surface of the set, which prevents, or at any rate considerably retards, evaporation of moisture.

He then discusses the merits of storing seed in boxes commonly called 'boxing' the seed, as against 'pieing' or storing it in heaps or pies. He advocates 'boxing,' especially where early varieties have to be dealt with, and shows that this method gave a considerable gain over 'pieing.' It moreover minimises the damage to sprouts, and the destruction of the seed by rotting, which often takes place to a large extent in 'pies.' In India 'pieing' is entirely out of the question, as the potatoes would at once 'heat' and rot. They are usually stored under shelter in single layers on shelves made of split bamboos, allowing plenty of ventilation and a moderate amount of light. The seed generally sprouts before sowing time, and the removal from the shelves causes the destruction of the majority of the shoots. To overcome this difficulty and also in order to gain the advantage of an early start, the writer tried the experiment of 'boxing' the seed, and obtained the most satisfactory results. The boxes or trays, after being filled with single layers, were placed in the bamboo shelves. The sets sprouted and were carried in situ to the field, where they were carefully planted. The great advantages of this method are (*a*) the sprouts are not injured in handling; (*b*) there is very little loss of seed by rotting; and (*c*) the crop is earlier by a fortnight to a month, a matter of great importance where the production of early varieties is desired. The adoption of the method is indispensable where potatoes are being grown in India for the English market.

Mr. Stewart lays stress on the importance of a change of seed. This precaution is of even greater necessity in India, where the tendency to degeneration in a plant is greater than in a cold climate. In this country the use of fresh seed every year seems advisable.

Mr. Stewart discusses the difference in results obtained from mature and immature seed. In 1904 he obtained seed in an *immature* state by lifting the potatoes while the tops were still green and the skin of the tubers tender. For *mature* seed the same varieties were lifted at the usual time, when the tops were quite dead and the skins of the tubers tough. He obtained a very slight advantage from the use of immature seed produced in this way. He found that it could best be obtained by planting a late patch of potatoes. The produce from such a plot was mostly composed of 'seed' and 'small,' well adapted for seed purposes. The explanation given for the better results from immature seed, is that "they may contain more innate vigour than a small yet fully-matured potato not yet arrived at its full growth."

Mr. Stewart also deals with the choice of varieties, the use of fertilizers and other matters, but as his remarks do not apply to the conditions obtaining in this country, reference to them has been omitted.—(B. C.)

* * *

AGAVES IN THE PUNJAB.—The results of the trials of four varieties of agaves grown at Lahore are instructive. The percentage of fibre given by each variety was *Agave Americana* 1·55 ; *A. Americana* (narrow leaved) 1·80 ; *A. vivipara* 1·87 ; and *A. rigida var. Sisalana* 3·27. Sisal thus showed its great superiority as a fibre yielder.—(B. C.)

* * *

BARE FALLOWS.—Professor A. D. Hall, of Rothamsted, has a very interesting note on this subject in the Journal of the Board of Agriculture for April 1906. It appears from his account that the practice of taking a bare fallow as a preparation for wheat was at one time an almost universal custom in farming. It was said to have been introduced into the British Isles by the Romans, and in mediæval times the only rotation consisted of wheat, barley, fallow, with beans instead of barley on the stronger lands. Towards the close of the eighteenth century the custom began to decline ; green crops and turnips in particular had become part of routine farming, and the four-course system of turnips, barley, clover and wheat, began to spread over Great Britain. The more advanced farmers perceived the importance of keeping the land under crop, and the writings of Arthur Young, who was Secretary to the then Board of Agriculture in the early years of the nineteenth century, were unceasingly directed against bare fallows, with the result that the culture of turnips and mangels spread considerably. Experience, however, demonstrated in time the benefit of fallow, and the area under it gradually showed a tendency to increase. According to Prof. Hall a bare fallow may exert a beneficial effect on the land in three ways—by cleaning the land of weeds, by improving the texture

of the soil, and lastly by increasing its fertility. An explanation of the last advantage was, however, not possible until the discovery of nitrification some twenty years ago, and the investigations since made into the conditions favouring the process. All soils contain considerable residues of nitrogenous materials, which cannot reach the plant until they have been oxidised by various bacteria in the soil and so converted into nitrates. A summer's fallow in England provides conditions favourable to nitrification—warmth, æration, the stirring of the soil, and the greater amount of moisture which results from the absence of a crop in dry soil. The following results of certain plots at Rothamsted in 1904 show that fallowing leads to a great gain of water to the soil :

	Percentage of Water in fine soil.	
	Cropped.	Fallow.
1st depth of 9 inches	17·4	17·2
2nd do. do.	18·8	20·0
3rd do. do.	20·1	22·3
4th do. do.	20·9	23·1

The chief gain, however, from a summer fallow lies in the way nitrates are made and stored up in the soil for the benefit of the ensuing crop. The Rothamsted experiments illustrate the increase thus produced :

	Wheat every year.		Wheat after fallow.	
	Grain.	Straw.	Grain.	Straw.
	Bushels.	Cwt.	Bushels.	Cwt.
Average crop per acre per annum, 1856—1902 ...	12·7	10·0	17·1	14·2

It should, however, be observed that as the benefit of fallowing depends upon the formation of nitrates during the summer and their retention for the next crop, it follows that heavy rain during the winter may wash them entirely away and leave the land no richer. When followed by a dry autumn, the fallowing may produce an increase of more than half in the ensuing crop, whereas if the winter be wet, the increase is little or nothing.

Thus in England the summer fallows are only likely to be of direct benefit to the next crop where the climate is dry and no great amount of percolation takes place through the soil in the winter. Professor Hall adds

an example to show how much more advantageous it is to grow a clover crop in the place of a bare fallow, and concludes his remarks by saying that "a bare fallow can never be a directly profitable operation, and has no justification on free working land. But with strong clays in dry climates, it may often be necessary to clean the land and restore its friable texture; on such soils too there is least likelihood of loss through washing out of reserves of nitrogen which have been rendered available by the process."

These conclusions are no doubt entirely correct as regards England, but it may be worth while to consider the results of fallowing in India. The chief gain in fallowing is no doubt due to the same causes in India as in England, namely, the conversion of nitrogenous material into nitrates by the action of bacteria. This action is carried out in India under very much more favourable climatic conditions of heat and moisture, and it may safely be assumed that the production of plant food is, therefore, greater than in England. But the most important difference resulting from fallows in the two countries would probably be due to the difference in the movement of the moisture. In England, as Professor Hall observes, heavy rain may entirely wash away the products of nitrification. In many parts of India, however, and specially in the alluvium tracts, it is doubtful whether this is the case. Percolation in the true sense of the term can hardly be said to exist in these soils. The moisture during the heavy monsoon rains carries the soluble constituents along with it to a considerable depth, but on the cessation of the rains, this moisture, aided by the rapid evaporation caused by the heat of the sun and dry winds, assumes an upward movement and probably brings back to the surface, and renders available for the use of the plant, the salts which under conditions of percolation would have been lost. These considerations, and the fact that fallows are practised with such conspicuous success in India, induce an opinion on their utility in this country very different to that which Professor Hall holds in regard to the same practice at home. The process of fallowing in India will commence with the breaking up of the land after the spring crop is taken off it. The soil is then ploughed and weathered with a view to killing weeds, aerating, and completely driving the moisture away until the rains break in June or July. It will then be repeatedly ploughed and weeded during the monsoon, the neglect of these operations being highly detrimental to the making of a good fallow. Towards the end of the rains the new crop is put in, and the results obtained are in every way as good, if not better, than could have been obtained by the growing of a crop and the application of heavy manuring. Indeed, in the case of a crop like tobacco, results are never considered satisfactory without fallowing. Although a strict scientific investigation of the

action of fallows in India has yet to be made, there can be little doubt as to their value, and they supply strong evidence of the importance of the biological study of soils, a subject which is beginning to attract the attention of many.—(B. C.)

* * *

FRUIT IN THE NORTH-WEST FRONTIER PROVINCE.—Some interesting information has been received from the Revenue Commissioner concerning the fruit cultivation and trade of the North-West Frontier Province. The total area under fruit orchards is estimated at some 4,000 acres, of which no less than 2,700 acres are situated in the Peshawar district. The chief varieties of fruit grown in the several districts are :—

District.	Kind of Fruit grown.
Peshawar	... Grapes, peaches, Orleans plums (*alucha*), quinces, pears, figs, pomegranates, water-melons.
Hazara	... Apricots, loquats.
Kohat	... Grapes.
Kurram	... Grapes, *shatil* (a kind of peach).
Bannu	... Grapes, figs, dates.
Dera Ismail Khan ...	... Figs, pomegranates, dates.
Tochi	... Mulberry.

The produce of the last four districts is generally consumed locally, owing to their isolation from the railway. Dates from Dera Ismail Khan, however, find a market in Multan and other neighbouring districts. Apricots from Hazara and grapes from Kohat are sent to short distances as far as Rawalpindi and sometimes to Lahore. The only district, therefore, which exports fruit in considerable quantities is Peshawar.

The system of fruit cultivation is crude, quantity and not quality being the only object aimed at. An occasional grower has attempted to introduce improved varieties. Pomegranate is the fruit most extensively cultivated, and the Peshawar pomegranate is now considered to be superior in quality even to that of Jelalabad. However, it hardly justifies its local name of *Bedana* (seedless). The principal varieties of grapes are *Bedana* white and *Bedana* black with round berries, and *Husaini* with long oval berries. The two former are most liked for the export trade.

The annual exports of fresh fruits from Peshawar are estimated in maunds at pomegranates, 37,500 ; quinces and pears, 37,500 ; grapes, 4,500 ; peaches, 4,500 ; Orleans plums, 1,500 ; total, 85,500 maunds (3,130 tons). Pomegranates are exported to the whole of India and as far as Rangoon, quinces are mostly consumed in the Punjab, whilst pears go to Rangoon ; the export of grapes and peaches is generally limited to Northern India; a small quantity only being sent to Calcutta, as they do not keep longer

than about five days ; for the same reason, plums are mostly exported to the Punjab, only selected fruit being despatched to Calcutta. The whole of the fresh fruit exported is not the produce of the North-West Frontier Province. A considerable portion of the transborder fruit imported to India comes to Peshawar ; this chiefly consists of dried fruits (almonds, raisins, nuts and the like), but also includes musk-melons, grapes and pomegranates. A special fruit van is booked every day from Peshawar to Howrah during the busy months of September, October and November, in the height of the pomegranate, quince and pear season, which carries about 5,000 maunds a month. This is an ordinary railway van with no special arrangements for the preservation of the fruit during the journey. Fruit consigned to other stations travels as ordinary parcels. Complaints are frequently made of pilfering during the railway journey.

The trade is said to be steadily increasing, but the great drawback is the primitive system of packing and grading. Grapes, peaches and plums are packed in baskets made of reed grass to contain quantities of about 20 lbs. The basket is lined with green leaves or dry grass, the fruit being packed in layers, each covered with leaves or grass. Some dealers have recently commenced to pack grapes in small boxes lined with cotton after the fashion followed in Kabul, but the practice is still very limited. Pomegranates, quinces and pears are packed in crates, made of four strips of wood at the corners with a top and bottom, all covered with matting. Each crate contains about 100 lbs. of fruit. There is no knowledge of modern systems of grading and packing.

This short account of the Peshawar fruit trade shows that it has already reached fair dimensions, and there is ample room for its expansion. There is a large market down-country, which could be supplied by the North-West Frontier Province at remunerative prices, if the systems of cultivation, grading and packing are improved. At present much of the fruit grown is not suited to travel any distance. The districts of Peshawar and Hazara are in particular suited to fruit cultivation, and could raise large quantities of grapes, peaches and other fruits, for which there is a considerable demand. The improvement of the fruit industry will be one of the most important functions of the recently created Department of Agriculture of the North-West Frontier Province, with its experimental farm at Peshawar. And when the Imperial Fruit Expert is appointed, his principal duty will be the improvement of the fruit of the temperate zone of North-West India.—(F. G. S.)

LITERATURE.

ANNUAL REPORT OF THE CIVIL VETERINARY DEPARTMENT FOR THE YEAR 1904-05.

THE improvement of Indian agriculture is so closely connected with agricultural stock that the working of the Civil Veterinary Department is of particular interest to agriculturists. It is, therefore, satisfactory to find that the last annual report of the Civil Veterinary Department records marked progress in all branches of work. In past years the energies of the department have been almost exclusively devoted to the encouragement of horse-breeding, which is a matter of great importance to the Army and to some parts of India, but which resulted in the neglect of the very much larger interests of the agricultural population of all parts in cattle. Now that the Army Remount Department has taken over all matters connected with equine stock in the important horse-breeding tracts, the Civil Veterinary Department has been able to take up the much larger field of work connected with cattle.

The staff of both officers and subordinate establishments has been strengthened, but is still quite insufficient for the important duties entrusted to it. With the improvements contemplated in the existing Colleges and Schools, the arrangements for veterinary education will be fairly complete, for good training institutions will exist at Lahore, Bombay, Madras, Calcutta and Rangoon, which should be sufficient to meet the needs of all provinces. The prospects do not, however, seem to be sufficiently good to attract students without other inducements, for we notice that all the students at Calcutta, Madras and Rangoon are scholarship-holders. The general educational standard for admission is also very low everywhere except at Madras. With the reorganization of the subordinate establishment, it should be possible to raise the standard of admission and so secure students better qualified to undergo the course of instruction. The present stamp of Veterinary Assistant is hardly sufficiently well qualified, either in general or professional educational attainments, to perform efficiently the important duties expected of him. We understand that the prospects of the service will be improved by raising the scale of pay, by making it pensionable and by creating

superior appointments. This opportunity should also be taken to raise the standard of admission to the Veterinary Training Colleges.

The arrangements for the scientific investigation of cattle diseases are still inadequate to the needs of the country. There are at present only two research laboratories, Mukteshwar and Bareilly, where a very small scientific staff is employed. We should like to see a research laboratory established in connection with each College, and the scientific staff strengthened so as to permit of both teaching and research work at each institution. We understand that laboratories have been, or will be, established at Lahore, Bombay, Calcutta and Madras, but this will lead to little practical result unless the staff is strengthened, so that officers can devote some portion of their time to research into cattle diseases. There is no branch of veterinary work more likely to lead to practical benefits to Indian agriculture than the scientific investigation of the many tropical diseases of cattle, which cause such enormous animal losses. The published returns of the deaths of cattle from contagious diseases are admittedly quite incomplete, and the improvement of the system of registration is a matter which deserves attention. The work already accomplished at Mukteshwar is evidence of the practical results that may be anticipated from similar work on an extended scale. It has already resulted in the preparation of sera for rinderpest, anthrax and hæmorrhagic septicæmia, the first two of which are rapidly coming into general use, no less than 75,333 animals having been inoculated in the past year, of which only 373 died. All opposition to this method of treatment is said to be rapidly disappearing, so that there should be a very large field for its extension.

The Government Cattle Farm at Hissar, the management of which has been placed upon a more efficient footing, is doing a great work for Northern India in the breeding of good bulls for sale and distribution. The large breeding herd, which is rapidly being raised to the highest standard, produces stock such as cannot be obtained anywhere else in India. A small start has also been made in establishing in other parts of India cattle farms for the breeding and rearing of bulls. This is one of the most promising lines of work for the improvement of cattle, but it must be prosecuted with due judgment, for success at one farm does not necessarily mean that others will be similarly successful. Before a cattle breeding farm is started, a full inquiry should be made into the local conditions under which cattle are bred and obtained. Some parts of India are entirely unsuited to cattle breeding, whilst in others the supply of good bulls is already sufficient to meet the demand. The best test is probably whether there is any large demand for good bulls, which a Government farm could meet. At the present time there seems some danger that the policy of starting cattle farms may be pushed to

undue extremes. The cattle survey of India has been completed in the Punjab and Burma only ; such a survey should be insisted upon before a cattle breeding farm is started in any tract.

There has been a considerable increase in the number of dispensaries and of the number of cases treated at them, but the success of this branch of work is still very small. The average daily attendance of out-patients is only $2\frac{1}{2}$ patients at each dispensary, whilst the total number of both in-door and out-door patients averages only 957 a year. The causes of the unpopularity of veterinary dispensaries seem to demand inquiry.

This has an important bearing on the question raised at the last meeting of the Board of Agriculture, whether the staff of veterinary assistants can best be employed at fixed dispensaries or on peripatetic work in the district. There can be no doubt that, if funds are available, both branches of work should equally be carried on, but with a limited staff it would seem that the general body of agriculturists would derive more benefit from peripatetic work than from stationary dispensaries. The benefits of the latter are mostly confined to the population of the towns in which they are located, the large majority of animals treated being the property of a few well-to-do European and Indian inhabitants. This leaves the great bulk of the agricultural stock entirely untouched by this branch of the work of the department. It is true that veterinary assistants at dispensaries can be more easily supervised than those employed on peripatetic duty, but the remedy for this is a larger supervising staff and better trained assistants. So long as the subordinate staff are maintained by local bodies, district councils and municipal committees, their wishes must be considered, and as the members are generally residents of towns, their interests are concerned more with dispensaries than with peripatetic work. At the same time, we hope that the development of the department will not take the form of the establishment of additional dispensaries, which have been largely a failure in the past. The treatment of the individual sick animal is a matter of minor importance to the country compared with the advantages that would result from the suppression of the disastrous outbreaks of contagious disease. Indeed, the department should contemplate the time when, at least in the large towns, the treatment of individual sick animals may be left to private practitioners and not be the duty of a Government department. For the suppression of cattle plagues, development is required upon other lines ; first, research both at laboratories and in the field, and second, an organization for the introduction into general use of the results of such research. This organization involves the concentration of a considerable staff at the localities of cattle-plague outbreaks, which is impracticable when all the veterinary assistants are stationed at dispensaries

and are only available for service in the district under the management of each local body. Each Superintendent should have at his disposal an adequate staff of assistants for employment at outbreaks of cattle disease, wherever they may occur in his circle. For such purposes it may be necessary to provincialize this section of the staff instead of employing them under local bodies. When not engaged upon the suppression of cattle diseases, this establishment could be utilized in making cattle surveys.

Indeed, the energies of the department seem at present to be devoted too much to the treatment of the individual sick animal, both at the dispensary and on tour, to the detriment of larger and more important duties. We should like to see the policy of the department framed on broader lines, which should include a full inquiry in each tract into the local conditions of cattle breeding, feeding, management and the like. Such an inquiry could hardly fail to result in many practical suggestions for the improvement of the cattle. And in the treatment of disease, we believe that more good will result from a well-considered plan for dealing with cattle plagues rather than from dispensaries for the treatment of individual sick animals.—(F. G. S.)

*
* *

Report on the Sugar-cane Experiments in the Leeward Islands, Season 1904-05.—Although in India new varieties of sugar-cane have never been raised from seed, in the Leeward Islands the ease with which the cane seed germinates makes the production of new varieties of cane a much simpler matter, and indeed provides the planter with so many new varieties that he has not so much to be encouraged to discard the old sorts, as warned to be careful what he will select to take their place. The Imperial Department of Agriculture for the West Indies, however, supervises the very thorough testing which these numerous seedlings undergo, firstly, before they are grown under field conditions at all, and afterwards when they are grown as a field crop alongside the older canes under the same conditions of soil, moisture, tillage and manuring.

The report on sugar-canes in the Leeward Islands for 1904-05 deals with the experimental trial on a field scale of a number of selected varieties of sugar-cane, with a view to providing canes for cultivation which shall be heavier in yield, richer in juice and more resistant to diseases and pests than the varieties at present in vogue. The experiments are conducted at various estates in the islands of Antigua and St. Kitts, and it is important to notice that they are carried out by the planters themselves, the methods of cultivation employed being the same as for the ordinary cane crop of each estate. Since ratooning is the common practice of cane cultivation in the West Indies, the canes are kept under observation for as long a period as possible.

Not only is the ratooning quality of the variety thus accurately determined, but the influence of season may be noted ; some canes, for instance, were better able to withstand the dry season of the year under report, and are found higher up in the list than their average place for four years, while as regards others the converse is the case. The highest yield of sucrose was from the cane named B. 156 which produced 5,578lbs. of sucrose per acre as the mean of 15 plots, whilst the White Transparent (Caledonian Queen) produced only 4,217lbs. sucrose per acre ; owing to the dry season these were considered to be only half crops. In St. Kitts, White Transparent was nearly the best at every station where it was grown, with an average yield from five stations of nearly 8,000lbs. sucrose per acre. B. 208 did better than White Transparent on the average results, but was not so consistent.

It is a most satisfactory proof of the progress made in such work that out of nine canes introduced in 1901-1902, five are amongst the seven recommended by these experiments as reliable canes, thus showing the value of the preliminary trials in selecting canes worthy of consideration by the planter, which canes by the experiments above recorded are quickly introduced into cultivation and oust the older and less profitable varieties.—(R. C. W.)

*
* *

REPORT ON SERICULTURE IN BARODA. BY N. G. MUKERJEE, M.A., M.R.A.C., F.H.A.S., *Government Press, Baroda.*

Small experiments in sericulture at Songadh in the Tapti Valley of the Baroda State having given promise of success, the Baroda State secured the services of Mr. N. G. Mukerjee, Assistant Director of Agriculture, Bengal, for a period of three months, to investigate the possibilities of the introduction of a silk industry into the Baroda State. The results of his investigations are given in this report. Mr. Mukerjee considers that the climatic conditions of some parts of the south of the Baroda State, notably the Naosari and Amreli districts, are quite suitable both for the growth of mulberry and for the rearing of silkworms. The report lays stress upon the conditions of temperature necessary for the successful rearing of silkworms, a mean temperature of 75° F. with no variations between the limits of 60° and 90° in the rearing house being stated to be essential to the production of the best cocoons. He has framed a scheme for the introduction of a silk industry into the Baroda State, which includes the establishment of two schools at Viyara and Songadh, where students will be taught the methods of both silkworm rearing and silk-reeling, the starting of mulberry plantations for the distribution of young plants, the publication in Gujerati of a manual of practical instructions, and ultimately the establishment of

a reeling factory on a large scale. Given suitable conditions and a supply of mulberry, which will grow well in most parts of Baroda, the success of the industry will depend upon the initiative of private persons in rearing cocoons under proper conditions and also upon the initiative of the State in providing first experienced reelers and later perhaps a steam reeling factory. Mr. Mukerjee deprecates the system of producing coarse silk by reelers whose work is not tested and who are not under supervision. Under proper management, a high quality of silk may be reeled, which will find a market in India and Europe and realise better prices than would the coarse silk used only in Indian silk weaving factories. The report is not quite clear as to course which the author would recommend. Two schools and the trained students now available will, apparently, be able to train additional students who will at once be set up by the State as silk rearers and reelers. There is some possibility that a steam reeling factory may not be required, and the author, though suggesting the factory, is of opinion that 100 to 150 trained men set up in suitable places will be sufficient to establish the industry among the people. In the event of this failing, the State is to establish a steam reeling factory and buy cocoons. Probably the officers of the Baroda State have a clearer idea of their best course of procedure, and we may hope to see some line of action actively prosecuted, until the success or failure of the industry is clearly shown. There are two alternatives:—first, to train men in rearing only and rely upon a factory for reeling; secondly, to train men both in rearing and reeling with the object of encouraging a cottage industry, trusting to expert advice and supervision to maintain a high standard of reeling.

Mr. Mukerjee recommends the cultivation of mulberry trees in preference to the shrubs at present grown in Bengal. Whilst this recommendation is supported by many arguments, it has yet to be proved by actual experiment that the growth of trees is commercially more profitable than the system universally followed in Bengal of growing shrubs, which give numerous crops of leaves from heavy prunings. Mr. Mukerjee has also made a change in the Bengal reeling machine, which is claimed to be a great improvement. At present, a second person is required to work the winding wheel, whilst the reeler manipulates the cocoons; but Mr. Mukerjee has invented a pedal arrangement by which the reeler can also work the winding wheel. No figures are given to show that this improved machine has been tested by a careful trial against the common reeling machine. It is desirable that this should be done at an early date and the results published for general information. If it is successful, it will be an important improvement in the Bengal industry.

The introduction of a new industry, requiring the minute care and attention to details that is essential to success in silkworm rearing, is a matter of great difficulty, but the prospects in Baroda State are sufficiently favourable to justify the efforts.—(F. G. S.)

*
* *

THE COTTON BOLLWORM. BY A. L. QUAINTANEE AND C. T. BRUES.—*U. S. A. Department of Agriculture. Bureau of Entomology, Bulletin* 50.

The cosmopolitan pest known as the Bollworm in the United States forms the subject of an elaborate and thorough memoir, worthy of the foremost Agricultural Department of the world. In India this pest is not known to attack cotton, though it eats a variety of plants including many which it attacks in the States. Cotton, corn, tomatoes and tobacco are its chief foodplants in the United States, and the loss caused by this pest is very large. So cosmopolitan has this pest become that it is impossible even to hazard a guess at its original home. It is as likely to be a native of India as of any other part of the world, and it is so at home in all quarters of the globe that it has peculiar parasites in various localities.

The methods of control advocated in the bulletin are mainly based on changes in farm practice so as to circumvent the insect. These measures are based upon a close study of local conditions and are not of universal application. The principle is the same everywhere, but its application depends for success upon a high standard of intelligence in those who are to practise such measures.

In addition, the use of trap crops is advocated, as well as the application of arsenical poisons. The latter is probably equally efficacious against the bollworms of Indian cotton (*Earias fabia and E. insulana*). It is disappointing to find that no new methods, no new principles of control are elaborated by the painstaking work of the authors of this bulletin, and the conclusion may not unjustly be arrived at that only by study from new points of view will any progress now be made.—(H. M.-L.)

* *
*

THE MEXICAN COTTON BOLL WEEVIL. BY W. D. HUNTER AND W. E. HINDS.—*U. S. A. Department of Agriculture. Bureau of Entomology, Bulletin* 51.

This bulletin of over one hundred and sixty pages, an amplification of a previous bulletin, is published at the instance of Congress. It is a very detailed account of all that is known about the Mexican Cotton Boll Weevil up to the close of 1904, presumably as a source of information for Entomologists and all who are interested in this pest. As an instance of a detailed study of a very important insect, the bulletin is admirable ; the most intimate

details of the life of the insect are discussed. Apparently even this minute study of the pest has not led to the discovery of any new principles in methods of treatment, and we may hope that the extremely elaborate work that is being done in the United States will ultimately be thoroughly assimilated and applied by the Entomologist or one of his staff. The present workers have evidently become so absorbed in detail that the main issues hardly appear.

The Mexican Boll Weevil is notorious owing to the short period occupied in establishing itself as the most serious pest of cotton in the New World. The damage caused by it in 1904 is estimated at six and a half crores of rupees ($22,000,000), and it has steadily increased in destructiveness during the past five years.

It may be hoped that this insect will never spread outside the New World. It is now known from the United States, Cuba, Mexico and Guatemala. There is a very evident danger that the insect may be carried over the world in cotton seed, the result of which may be simply appalling. If its destructiveness is so great in the United States where it has some enemies, it would be far greater in Egypt, East Africa or India where its enemies will be non-existent.—(H. M.-L.)

*
* *

TWENTY-THIRD REPORT OF THE STATE ENTOMOLOGIST, ILLINOIS, U. S. A. *A Monograph of Insects Injurious to Indian Corn. Part II.*

In this volume, Mr. S. A. Forbes reviews the insects which live upon the maize plant, including not only those which seriously affect the plant, but also the minor and unimportant pests. The author has in fact prepared a monograph of the insect fauna of the maize plant, so that a large number of insects are discussed.

Under "Insects Injurious to the plant above ground" sixteen "cut worms" (surface caterpillars) are included, including the common Indian species, *Agrotis ypsilon.* The world-wide Army worm (*Cirphis unipuncta*, Haw.) is another insect common in India, which is here stated to be "one of the most destructive of the insect pests of American Agriculture." Another widespread pest is the Corn worm (*Chloridea obsoleta*, F.), better known as the American bollworm of cotton ; of this the author states that "the mastery of this pest in the corn field is still an unsolved problem." This is the caterpillar found so abundantly in India on gram, and which was widely destructive to this crop during the past cold weather.

The author also deals with the root webworms, the burrowing webworms, the stalk borer, the corn bill bugs, the chinch bugs and several species of grasshopper, making up a large total of insects of major importance injurious

to the crop above ground. If we add the insects injurious to the plant below ground (discussed in Part I.), the enemies of this crop become very numerous. Since the volume deals with the fauna of one State alone, it becomes evident that the magnitude of the work amply justifies the great attention paid to nomic entomology in the United States.

In dealing with the less important species, the author mentions a further formidable list of species. There are no species in this list which are also common to India, but there are what may be called equivalent species, *i.e.*, species which are extremely closely related and which work in the same manner in both localities. The Indian mothborer (*Chilo simplex*) has its counterpart in the American stalk borer (*Diatræa saccharalis*) ; the hairy caterpillars of India (*Diacrisia and Amsacta*) are represented by the " Wooly Bears ;" the flower beetle of the East (*Chiloloba acuta*) is similar to the flower beetles and green June beetles (*Euphoria and Allorhina*) of this report ; Blister beetles occur in both localities as do the plant bugs ; the maize Fly (*Delphax psylloides*) of India differs little from the corn Delphax (*Delphax maidis*) of Illinois, and so on. We do not yet know all the Indian pests of maize, but it seems certain that the number cannot equal half that mentioned by Mr. Forbes.

In another group, the author discusses a very long list of insects " whose presence is not merely accidental but which do not injure the corn plant in any way to give them any appreciable economic importance." This section of the report is of extreme interest as showing what a large fauna gathers in a wildly-grown plant such as maize, and how varied is the insect life which lives in connection with such a plant.

Mr. Forbes' report is an example of the work that should be done in India, the detailed and prolonged investigation of the enemies of a single important foodplant by an observer who can give his attention to this particular research alone. The report is admirably illustrated, the excellent coloured plates adding much to its usefulness.—(H. M.-L.)

* * *

* AMERICAN INSECTS. By VERNON L. KELLOGGY.

This general text-book on Entomology appeared in 1905 and is the most recent of the series of volumes that have from time to time condensed into a small compass a general view of the enormously variable insect world. Putting aside the complex system of classification, the volume is a readable and trustworthy account of the main activities of the insect world of the American continent. As is usual in an American volume, the system of classifica-

---

* A continuation of the reviews on pp. 178-183 of this volume.

tion differs so much from that in general use in such volumes as Sharp's "Insects" that the student is likely to be confused. In other respects the volume is one that should be of special value in the hands of students of entomology in India, the bionomics of insects being very prominently kept in view. No single volume can do more than give a general picture of some part of the activities of the insect world, and the author gives a readable account of the living activities of a very representative number of the insects of the American continent. The chapters on "Insects and Flowers," "Insects and Diseases," and "Colour and Pattern and their Uses" are excellent, and apply as closely to India as to other parts of the globe. The keys to the sub-divisions and the systematic entomology generally are best passed by, as they are naturally totally inapplicable to a tropical and oriental fauna such as that of India. As a reference book to the habits of a family, as an eminently readable review of the activities of the insect world at large, the book is worthy of a place, with those reviewed in earlier pages of this journal, on the shelves of an Agricultural College library.—(H. M.-L.)

***

Annual Report of the Indian Section of the Imperial Institute for 1904-05.

This report gives an account of the work done for India at the Imperial Institute during the past year. Investigations have been made to determine the composition and commercial value of manganese ores, pottery clays and laterites, and the constituents of a large number of Indian coals have been determined. The investigation of the tanning materials of the barks of two common forest trees—*Shorea robusta* and *Terminalia tomentosa*—resulted in working out a process by means of which an extract may be prepared from these barks which produces satisfactory leather; this may prove a matter of considerable importance, if the process can be worked on a commercial scale in India. Numerous reports were furnished on samples of Indian fibres and rubbers. An India Trade Enquiry Office has been opened at 73, Basinghall Street, in the heart of the City of London, where any person can obtain information on Indian trade and commercial matters. The rearrangement of the Indian collections at the Imperial Institute is in progress, but much remains to be done to render the exhibits representative of the important resources of the Indian Empire. A special Cotton Exhibition has been arranged to illustrate the progress which is being made in the growth of cotton in the British Colonies and Dependencies and to exemplify the commercial uses of cotton It is hoped to

improve and increase the samples representing the various types of Indian cotton and the fabrics made from them.—(F. G. S.)

*
* *

HISTORY AND DEVELOPMENT OF AGRICULTURE IN THE MALAY PENINSULA. BY H. N. RIDLEY, M.A., F.L.S., *Director of Botanic Gardens, S. S.* (Agri. Bull., Vol. IV, No. 8.)

Agriculturists, who are sometimes sceptical as to the practical value of the work carried on by Botanic Gardens, would do well to read Mr. Ridley's able article. In a recent report on the Agriculture of the Malay States, Mr. Ridley considers that sufficient credit was not given to the work done by the Botanic Gardens in Singapore. He has, therefore, been at pains not only to trace the general history of Malayan Agriculture, but also the individual history of all the crop plants grown now or formerly in the Peninsula.

Mr. Ridley lays emphasis on the important fact, which those who decry or fail to appreciate this kind of work would do well to bear in mind, that the lessons taught by such institutions must be negative as well as positive ; to quote his own words, " the knowledge that a plant of economic importance will not thrive in this country, is of nearly as much importance as the knowledge that it will prove successful." Dealing then with this one side of the work of a Botanic Garden, namely, the introduction, testing and distribution of exotic plants likely to prove useful in general cultivation, Mr. Ridley shows what has been done in the case of the Malayan Peninsula.

Though scraps of information may be gathered from scattered sources about the agriculture of Malay under Portuguese and Dutch administration, it was not until the appointment of Christopher Smith to the Botanic Gardens of Penang at the beginning of the last century that we find any really systematic work was done. From then until the appointment of Mr. Menton in 1875 to the Singapore Botanic Gardens, the history of Malayan agri-horticulture is a disheartening one. Sir Stamford Raffles founded two Botanic Gardens, one at Ayer Hitam in Penang in 1822, and one at Singapore in 1823, but with his retirement progress began to dwindle. Since Mr. Menton's appointment, however, progress has been rapid, and the Peninsula is now in possession of two well-organized institutions at Singapore and at Penang.

The value of the work done by these institutions, in introducing exotic plants to the notice of the planters, can scarcely be overestimated in a country where the system of agriculture is such as we find carried on in

Malay, where one crop at a time is grown to the almost complete exclusion of all others ; for if at any time it is found that the crop under cultivation ceases to be remunerative, it is of the utmost importance that no time should be lost in replacing it with thoroughly acclimatised and healthy specimens of some other crop. This may be looked upon as a special branch of the work of a Botanic Garden.

It may be well to call attention to an important economic principle which is well exemplified in the history of these States. For each crop of economic importance there is probably a locality where from conditions of soil and climate it may be grown most profitably ; until this is ascertained, other localities may at first grow it at a profit, but sooner or later the price will fall until a level is reached at which none but the most favoured locality can afford to grow it. Such was the case with Liberian Coffee, which dropped out of cultivation in the Malayan States when the vast output from Brazil caused the price to fall below a rate remunerative in Malay.

Mr. Ridley has called attention to the fact that the European planter and the native planter seldom cultivate the same crops. The European usually grows exotic plants and is seldom successful with the plants cultivated by the natives, while the latter seem to be too conservative to adopt new crops.

For the main object of this article, Mr. Ridley has succeeded in writing a most able justification of the Singapore and Penang Botanic Gardens ; and as an apology, using the word in its classical sense, for the general system of scientific Agri-Horticulture, the lessons to be drawn therefrom are far-reaching in their application.—(R. C. W.)

*
* *

THE FERMENTATION OF TEA, PART I. BY HAROLD H. MANN, D.SC., *Indian Tea Association, Calcutta.*

We welcome this very interesting pamphlet as an addition to the author's previously published works on the ferment of the tea leaf (The Ferment of the Tea Leaf, Part I (1901), Part II (1903), Part III (1904), Indian Tea Association, Calcutta). In his earlier publications Dr. Mann has shown that the changes which take place in the tea leaf during the manufacture of finished tea are mainly, if not entirely, brought about by the action of an oxidising enzyme on the other constituents of the leaf, that this enzyme is developed during the withering process, and that bacteria play no useful part in the operations and should be excluded as far as possible. In the present pamphlet the nature of the chemical changes taking place during the process is dealt with, and a somewhat complex subject disposed of in the same popular and practical manner which has characterised the author's former work.

It is pointed out that, so far as is yet known, only three constituents of the tea leaf go to determine its value—the essential oil, the caffeine, and the tannin. The first two of these substances are speedily dismissed since it seems that the essential oil is a little known body, and the caffeine, though perhaps of medical interest, is of little consequence in determining the trade value of a tea. The tannin is of more importance. Dr. Mann gives figures to show that the value of a tea may be directly traced to its contents of this constituent, since on it depend to a very large extent the pungency, the colour and the total dissolved matter of the liquor obtained on infusion. The pungency would seem to be conditioned mainly by unfermented tannin, the colour by fermented tannin, and the total soluble matter by both together. It, therefore, becomes of prime importance to trace the progress of the changes which take place in the tannin during the fermentation process, so that it may be regulated in such a manner as to produce a tea containing the most desirable quantity of this substance in the fermented and unfermented forms.

In order to do this, Dr. Mann has carried out a very careful series of experiments in withering and fermenting teas under varying conditions, estimating the total soluble matter and soluble tannin produced in each case. In connection with withering, it is found that both the total soluble matter and the soluble tannin continue to increase in quantity during the process, provided the leaf is kept moist and that no fixed maximum point is arrived at, as was found to be the case in the development of the enzyme. If the leaf is allowed to dry up, however, a reduction in the total soluble matter immediately takes place owing to oxidation of the tannin. Dr. Mann draws attention to the necessity which this indicates of avoiding bruising or breaking the leaf before and during spreading in the withering house, since, if this occurs, drying up will result around the wounds and a tea of reduced value be produced.

During the fermentation process, the tannin and the total soluble matter are found steadily to decrease until a fixed minimum is eventually arrived at. The rate of change is found to be considerably influenced by the temperature at which the operation is conducted, as well as, of course, by the heaviness of the rolling to which the leaf is subjected before fermentation, since thereon depends the amount of ferment and fermentable substance which are brought into contact with one another. It is shown that with a normally rolled leaf, the fermentation is complete (that is to say the soluble constituents have reached a minimum) in between five and six hours at 80°F., which has been found to be the optimum temperature at which to conduct the process.

Like other investigators into industrial fermentation processes, Dr. Mann was led away by the fascinating idea of conducting his fermentation at a

higher temperature than is usually employed, so as to hasten the process and, if possible, render it continuous ; but, again, like other investigators, he was doomed to disappointment. It was found that at a temperature very slightly higher than the optimum, secondary actions come into play, and dark brown undesirable products are formed due to superoxidation. The conclusion is, therefore, drawn that the fermentation should never be conducted at a temperature above 82°F., and, as an outcome of this, useful practical information is given as to the necessity for thin spreading in the fermenting house, and quick firing at the conclusion of the process. It is further concluded that in all "the plains districts of North-East India the idea of fermenting in the factory itself must be given up," since it seems hardly possible to ferment at the necessary low temperature in any practicable manner. Several useful hints are given on the construction of fermenting houses so as to attain the three main conditions which have been found desirable, *viz.* :—(1) the maintenance of a temperature of 82°F., or below ; (2) the production of a saturated atmosphere ; and (3) the provision of conditions as free as possible from injurious microbes, in other words, of extreme cleanliness.

Some interesting observations on the effect of light of various colours on the fermentation process are recorded. Doubt appears to exist as to the most desirable method of lighting the fermenting house, and windows of various colours have been adopted by many planters, whilst, in some cases, windows are excluded almost entirely. As a result of his experiments, Dr. Mann concludes that the fermentation is retarded by blue light, but that white, red, and yellow lights are without effect on the rapidity of the process, whilst the ultimate result is the same in every case provided direct sunlight and glare are avoided. So far as we are aware, this is the first case in which the effect of illumination on enzyme action has been studied. The subject seems worthy of further investigation which may lead to valuable applications to other fermentation industries ; useful information might perhaps be obtained, for instance, on the lighting of malting houses.

On this subject, as on several others with which he deals, one cannot but regret that Dr. Mann has not had the opportunity to give us some more exact scientific data. As a practical guide to tea planters, and as affording scientific explanations of many of their well recognised practices, the pamphlet before us is a model of what it should be, and doubtless it is right that it should be written with these objects primarily in view ; but there are several points on which we would welcome more detailed information, not only as assisting us to understand more fully the subject under discussion, but as enabling us to argue more readily from the case of tea to that of similar

problems. We cannot, for instance, readily grasp how the explanation given by Dr. Mann on page 5 of his report of the mode of action of the enzyme fits in with his observations, for, if the tannin of tea is a glucoside, it would seem essential that a hydrolytic enzyme be present to bring about the separation of the sugar ; mere oxidation can hardly account for this, though it may be, and evidently is, a secondary action. No doubt a description of the "many experiments" which Dr. Mann refers to as being "out of place to detail" would explain this. Again, we should like to have some experimental verification of Dr. Mann's statement that the tannin of tea is peculiar in not being precipitated by gelatin, and some details of his method for determining the carbonic acid gas exhaled by the tea leaf during withering, referred to in the footnote to page 7, would be very interesting.

But we are, doubtless, asking too much from a report designed to edify, and not to terrify, the members of the Indian Tea Association. We can only hope that a scientific officer in such an unique position in India as Dr. Mann, will see fit at some future date to publish in some scientific journal an account of the scientific details of his work for the benefit of his fellow-workers.—(C. B.)

THE ORIGIN OF NEW SUGARCANES BY "BUD-VARIATION."

By C. A. BARBER, M.A., F.L.S.,

Government Botanist, Madras.

One of the most striking facts connected with sugarcane cultivation is the enormous number of varieties which, though easily separable, have the greatest botanical similarity. It is frequently possible to distinguish two varieties without being able to put down clearly wherein the difference between them exists. The difference may be in the form of the joint, in the tinge of colour, in the habit of the plant in the field, in its thickness or height, in the richness of the juice expressed. Again, with no external differences at all, there may be such a difference in constitution that, whereas one cane grows clean and healthy and yields a certain crop, the other is swept out of the fields by disease.

Even after prolonged study it is difficult to decide how all these varieties have arisen. There is no doubt as to the ancient character of sugarcane cultivation. While it is probable that the cane was first cultivated in a certain Asiatic region, yet nowhere can we lay our hands on a *Saccharum*, now wild, which presents any probability of being the progenitor of the cultivated forms. The matter is not rendered easier by observing how peculiarly susceptible the sugarcane is to any change in its environment. We cannot tell beforehand in what direction changes are likely to occur, but certain it is that if two canes are taken from one part of the country to another, their characters under the new condition differ, whether in colour, form or sugar-making properties. The pet cane of one region quickly assumes a very second rate character in another, being left behind by a cane which could in no way be considered its rival in the land of its origin. Some improve in their juice and others deteriorate, some change their colour and others do not, while some really good canes dwindle to the size of the local "reeds" which are everywhere to be found where sugarcane has long been cultivated.

With these obvious facts before us, there is an entire absence of a good connected series of observations, and we have to confess that we know next to nothing as to the way in which the countless varieties of sugarcane cultivated at the present day have arisen.

From this point of view a study of the striped canes, or those which have two main colours alternating in their stems, appears most likely to lead to interesting results. And the first subject for investigation is to try and find out how these varieties have arisen. In all likelihood the yellow or green canes were the first obtained and cultivated, and the others arose as subsequent varieties. The assumption of a red colour by the rind of plants under cultivation is by no means an uncommon phenomenon. The striped canes would probably be the last formed, and there is some reason for supposing that each striped cane has for its parents two canes, a red and a yellow one. Such striped canes may have arisen in several ways. Firstly by seminal crossing. While seedling canes appear to be very rare in India, they are not at all uncommon in certain tropical islands; and it is fair to assume that in past times this seminal reproduction was much commoner than it is at present. The practice of growing canes of different varieties in the same field is probably very ancient, and we have a ready means by which the striped canes may have originated. That they have arisen late, among canes already cultivated, appears to be also probable from the fact that the striped canes as a whole are ones of good character from the milling point of view, and while there are numerous yellow and less frequently red canes of a reed-like primitive nature, such canes are hardly ever striped. But there is just sufficient evidence to render it possible that these striped canes have arisen from the apposition of two canes of different colours by natural grafting, and it is possible that some at least of the striped canes are in reality graft-hybrids. The general absence of grafts among monocotyledons renders this less likely but not impossible, and exhaustive experiments are called for to determine whether we may not by this method hope to raise new varieties. But the strongest argument in favour of the origin of striped canes from parents of two different colours is the not infrequent reversion of these varieties into canes of single colours. Such "sports" are by no means infrequent and form the subject of the present paper.

It is a matter of common knowledge among the Godavari ryots that in a field of *Namalu* (striped red and yellow) canes, sooner or later the number of *Keli* (yellow) canes increases. And when we take the Namalu and Keli canes and compare them from a botanical and chemical standpoint, it is difficult to find any real difference between them excepting in their colour. There is then a strong presumption that the Keli is a natural sport

from the Namalu. And it may be at once asserted that the tendency in the striped canes is always to produce yellow rather than red sports, a fact which seems natural when we consider that the yellow canes are probably the older and nearer to the original cane of the primitive cultivation.

The following canes have been noted in the short life of the Samalkota Sugar Station in the Godavari district. The cane known there as the "*Striped Mauritius*" has been seen frequently to sport into green canes and less often into canes of a pure red. A fortunate example of this is shown in the illustration. A striped set has, growing upon it, and all from a single bud, canes of three different colours, one red, two green or yellow and two striped. The bunch was dug up, carefully washed and photographed. The colours have been drawn in from the varieties grown on the farm. There are now good plots of all these canes, and they have been submitted to analysis for two years. There is no doubt that the three canes have sufficient differences, besides their colour, in the richness of their juice and in their habit of growth, to constitute well marked varieties in the ordinary sense of the term. It is quite in accord with what has been suggested above that the green is hardier, bunches more readily and has inferior juice, that the red cane on the other hand is little inferior, if indeed it is not superior, to the striped, which otherwise holds an intermediate position between the other two.

The thick striped cane called on the farm the "*Dark Striped Mauritius*" has also been identified as the parent of the yellow "*Ivory Mauritius*," but no red cane has yet been obtained from it. The long striped cane obtained from various parts of South India, called by some the "*Striped Singapore*", has sported into both red and yellow, but the characters of these have not yet been determined. Finally, the striped cane growing in Mr. Abraham Paudither's garden at Tanjore (which cane may be identical with the last named) has given rise to a new ashy cane which appears to be well worth cultivating.

This mode of origin of new cane varieties has been termed "Bud-variation." After observing the facts described above on the farm at Samalkota three years ago, my attention was drawn to an article in the West Indian Agricultural Bulletin where the subject was exhaustively dealt with. No analyses were, however, published of the different canes arising from bud-variation. As in the cases noted above, it was always a striped cane which showed this phenomenon in the West Indies, Louisiana and Mauritius. It is worthy of note that this bud-variation does not consist in certain buds growing out to form new canes of one colour, but isolated buds show *variability* and give rise to shoots of different colours, sometimes

indeed to a shoot whose base is striped but which becomes yellow in its upper part. The idea that a bud in the red part of a striped cane gives rise to a red cane, whereas one in the yellow part produces a yellow, is apparently not correct. The canes thus arising appear to retain their characters and have remained constant for three or four years already.

Now this fact that the striped canes have alone been observed to "sport" may be explained in two ways. On the one hand they may be true hybrids which have arisen from the crossing of the two one-coloured canes, and consequently may have a greater tendeney to vary than the one-coloured canes. But on the other hand the frequency of the phenomenon in striped canes may be due to the fact that, while such changes in colour are very readily seen in them, they would require very careful observation in the case of ordinary canes. And I think that the latter is more likely to be the explanation. If such is the case, it behoves us to study our fields with much greater care than heretofore. Whenever, in a uniform field, canes appear which show any marked differences from the rest, they should be carefully segregated, cultivated and analysed. A certain amount of work has been done in this direction at Samalkota, but the results thus far obtained have not been satisfactory. Chance differences which have been observed have not been maintained. But this is no reason why the subject should be dropped, and observations will be continued as opportunity offers.

With reference to the *Striped Mauritius* and its "*sports*," the more important figures in the two years' analyses have been reproduced in the table. The *Green Sports* may be classed as a cane distinctly inferior to the other two, whereas the *Ivory* appears to be distinctly better than the *Dark Striped*. The *Red Sports* during the first year showed such good results that it was thought that a new cane of great value had been discovered. It was accordingly named the "*Gillman*" after the Collector of Vizianagram, through whose energy and forethought these Mauritius canes had been introduced into Madras. These canes and others obtained in the future will be multiplied and, in due course, valued and added to those on the farm or rejected according as they turn out.

Analysis of striped canes and sports in the Government Sugarcane Farm, Samalkota.

Varieties.		Juice. Corr Brix.	Juice. Per cent sucrose.	Juice. C-P.	Juice. Per cent glucose.	Begass. Per cent obtained by crushing.
Striped Mauritius,	1904—1905 ...	20·44	19·33	94·57	·30	37·23
Ditto	1905—1906 ...	21·31	19·94	93·57	·67	37·53
Green sports	1904—1905 ...	20·29	18·66	91·96	·60	33·92
Ditto	1905—1906 ...	18·57	16·61	89·45	·93	34·79
Red sports	1904—1905 ...	21·35	20·23	94·75	·30	39·67
Ditto	1905—1906 ...	20·16	18·88	93·65	·67	34·48
Dark Striped Mauritius,	1904—1905 ...	17·06	13·98	81·94	1·54	36·87
Ditto ditto	1905—1906 ...	16·98	13·95	82·15	1·95	36·86
Ivory Mauritius	1904—1905 ...	18·67	16·11	86·29	·75	38·96
Ditto	1905—1906 ...	17·87	15·37	86·01	1·34	40·41

PROTECTIVE WORKS IN CENTRAL INDIA.

By H. MARSH, C.I.E.,

Consulting Engineer for Protective Irrigation Works, Central India.

"I AM disposed to think that the most productive parts of the surface of Bundelkhand, like that of some of the districts of the Nerbudda territories, which repose upon the back of the sandstone of the Vindhya chain, is (*sic*) fast flowing off to the sea through the great rivers which seem by degrees to extend the channels of their tributary stream into every man's field, to drain away its substance by degrees, for the benefit of those who may in some future age occupy the islands of their delta. I have often seen a valuable estate reduced in value to almost nothing in a few years by some new antennæ, if I may so call them, thrown out from the tributary streams of great rivers into their richest and deepest soils. Declivities are formed, the soil gets nothing from the cultivator but the mechanical aid of the plough, and the more its surface is ploughed and cross-ploughed, the more of its substance is washed away towards the Bay of Bengal in the Ganges, or the Gulf of Cambay in the Nerbudda. In the districts of the Nerbudda, we often see these black hornblende mortars, in which sugarcanes were once pressed by a happy peasantry, now standing upon a bare and barren surface of sandstone rock, twenty feet above the present surface of the culturable lands of the country."

Thus wrote Sleeman some seventy years ago about Bundelkhand. His remarks are still true, except where enlightened administrators have encouraged and assisted the people to check the denudation by the construction of embankments. Nothing strikes the observing traveller in Central India more than the depths of the great river channels, their tributaries and even the small rivulets that feed them. This physical character leads to disastrous effects in a country, specially prone to famine, which is gradually being depopulated. Not only do the deep rivers and their affluents carry off the good soil, as described by Sleeman, but they also lower the subsoil water level, so that wells dry up, and cause serious privations to man and beast.

Yet the position is not at all irremediable, and in this article I propose to state some of the measures likely to effect practical improvements.

The peasants are quite aware of the value of arresting the rapid drainage from their fields, not only for the purpose of conserving moisture for sowing and maturing the spring crops, but also as an infallible method of improving the fertility of the soil itself. Here lies, therefore, a prime opportunity for the various rulers of Central India to encourage this industry by every means in their power. In some States, I believe, considerable progress is reported where rulers have guaranteed proprietary rights in land protected by embankments, and in others useful State loans have been made with the same object. In British Bundelkhand and the Central Provinces, active measures have been taken for the construction of scientific field embankments to immerse areas of about 20 or 30 acres, and these efforts are sure to meet with success, if not neglected. But such action cannot have the same great effect, as would be obtained if the majority of cultivators could be induced to protect their own fields.

Where an embankment is made which affects the interests of several individuals, but is too small for State management, difficulties are sure to arise about its maintenance. One man wants to cut the bank of his immersed field so as to commence ploughing for the spring crop, whereas another wants to retain the water for his rice plants. Then, again, there is often trouble about the injury to standing crops from the escaping water, whilst the necessary annual repair causes difficulty unless there is a strong village headman to arrange about these matters. Thus, although large embankments are of immense value, and particularly so where there is an enterprising village headman, yet they do not have the same permanence as the small banks made by a cultivator round his own field. The truth of this statement is rendered patent by the many neglected embankments found in Central India. As an example, I may quote a few lines from my own notes in 1905, regarding Makhoni village in Datia State :—" About 1893 a Soukar called Sibhu made a lot of bunds in Makhoni, and then died. The heavy rain of 1894 burst them, and they have never been repaired. I think they could be put right for very little. At present, however, the village is without an enterprising man like Sibhu, and apparently nothing will be done until he turns up. The eastern half of Kheri has got into the hands of a strong Soukar, and there the bunds are in good order, and the wells are being worked with great effect."

Again, the following extracts from Mr. Impey's Settlement Report of the Jhansi District for 1893, show the immense value of small embankments :—" Though not exactly a source of irrigation, but rather a means of conserving the benefits derivable from rainfall, the system of field to field

embankments, found especially in Moth and the north of Jhansi, may here be mentioned. It can scarcely be said ever to have received the attention it deserves, for it is unquestionably of extreme value in protecting land against both erosion and kans, it recommends itself to the people themselves more than any other ambitious schemes, and it has a direct fertilizing effect."

* * * * * *

"Field embanking is the simplest of all matters. A small earthen 'bundh,' from 2 to 6 feet high, is thrown up along that side of a field, which is crossed by the drainage from the field. Flanks are added, if necessary; or if the slope be very inconsiderable, the field may be enclosed by bunds on all four sides. One or two feet of water can in this way be kept up until after the end of the rains, and the land is thoroughly soaked before the winter sowings. In some parts of Moth and the north of Jhansi, series of these small bunds are found all down prolonged drainage slopes, and the land over which they have effect increases in darkness and in fertility every year."

* * * * * *

"The advantages of the system are numerous. The people are willing to throw up the embankments, and to take takavi for them. The rain water is retained for the ground on which it falls, instead of scouring into nallahs; and as the nallahs are deprived of their supplies, they lose their velocity and power of cutting back into the good land above them. The productive power of the land is increased, and *kans**, where it exists, is drowned out."

I have consulted many skilled officers on the subject of this form of protection, who all agree that it is of the utmost value in tracts of good soil, but that the cost would not be recouped in areas of poor gravelly formations. Every one seems to think that field embankments will repay the outlay on fairly good soils (locally known as *mar*, *kabar*, *parwa*, and the yellow *rakar*), but not in the case of such poor soil as red 'rakar,' which is considered too porous. Still it seems a pity that the lastnamed formation should be allowed to be denuded and I recommend the employment of State labour on such work in times of scarcity or famine. A great gain must be effected, if the water is compelled to enter the subterranean reservoirs instead of rushing along the surface, increasing storm discharges in the nallahs and carrying off more good land. On this matter Mr. W. H. Moreland, Director of Agriculture, United Provinces, writes to me as follows:—"Turning now to the tracks where the soil consists of disintegrated rock more or less *in situ*, or south Bundelkhand as spoken of by your correspondents, I think myself they are inclined to underestimate the cumulative effect of retaining the finer soil particles, instead of letting them

* *Saccharum Spontaneum.*

wash off. The soils being too coarse in texture to hold water to the best advantage, it is obvious that retention of the finest particles means gradual amelioration, as disintegration progresses; while to let them wash out, means no amelioration and possibly deterioration. But there is another consideration, affecting the water supply in wells both for irrigation and for domestic purposes. Mr. Molony has gone closely into this point in his book on wells. I extract the following from his manuscript (now on its way to the printers) :—"In the rock well tract, *i.e.*, parts of South Bundelkhand, Mirzapur, etc., the underlying rock has not the same capacity for storing water as the sandy sub-soils of the Duab. Consequently, when a severe failure of the rain occurs, the evils of famine are often very much aggravated by a water famine. The only thing that can be done is either to prevent the rain running off into the rivers by holding it on the land where it falls, or by taking the water out of the streams and pouring it on to the land lower down by means of canals."

* * * * * *

"Another method is to make a number of small embankments, or field embankments, each of which will hold up a little water. Even if such embankments hold up the water for a few days or hours only, they may be the means of saving quite a considerable portion of the rainfall."

Enough evidence has now been brought forward, to show what solid improvements can be effected, even in the small States where expert engineering assistance is seldom available. The Irrigation Commission were quite alive to the value of such work, and have remarked: "The practice of embanking fields has received considerable impetus during the recent years of drought; and we have no doubt that if immediate advantage be taken of the present feeling in its favour, a great deal of valuable protection can be afforded to the province at a small cost."

* * * * * *

"More than one of our witnesses has stated that, on an average, embanking doubles the outturn."

"Again, two large embankments made in 1897 by Seth Nathu Ram, a Malguzar in the Saugor District, protected his village so effectively, that he not only kept his tenants on the land, but paid all his revenue in the year 1900, when his neighbours both lost many of their tenants, and failed to pay their assessment."

Turning now to a consideration of another form of protective work, I think that there is very fair scope for developing perennial irrigation in Central India by the construction of canals of moderate size. The Ken, Dassán, Betwa and Sindh rivers are all fed from extensive basins, covering

several thousand square miles. Even in the driest years, these rivers pass off immense volumes of water, far more than would be necessary for all required irrigation, if there were only reservoirs to hold it. Then again the physical conformation of these drainage arteries is peculiarly fitted to the construction of magnificent storage sites. For centuries huge floods have been broadening and deepening the beds, with the apparent object of eventually breaking the rocky barriers over which the water has to leap at intervals. We have, therefore, numberless reservoirs already roughly fashioned out by nature, and the engineers have been left with the simple task of equipping the rocks with the necessary masonry and gates.

The experience of the Betwa canal has taught the Irrigation Department that no reliance should be placed on the cold weather discharges of a Central Indian river. Advantage must be taken of the absolutely certain monsoon floods with their numerous opportunities of storing water, until the necessary volume is secured. With this object in view, the reservoir at Paricha was increased by 50 per cent in 1901, and in 1907 the capacity will be doubled by the construction of a new weir, already well advanced.

When this security has been reached, there is no doubt that the people will undertake the cultivation of sugarcane, early cotton and other valuable crops, and gradually approach the stage of comfort and affluence attained by the cultivators along the Jumna and Ganges canals. It is easy to show that Government will also gain by its activity in the matter. The Betwa canal was opened in 1884, but though of great use as a protective work against famine, its revenue was less than its cost of maintenance until 1903, when the results of the extra storage began to be felt. During the twelve preceding years the average annual area equalled 37,000 acres, but it has steadily increased to 64,000 acres in 1902-03, 78,000 in 1903-04, 118,000 in 1904-05, and 162,000 acres in 1905-06.

These facts indicate the truth of a well known remark of Sir Thomas Higham, K.C.I.E., late Inspector-General of Irrigation, when he stated that to make a canal successful, money must be poured in as well as water. I am in great hopes, therefore, that surveys now in progress will prove that invaluable protective works are possible from the Sindh river, from the Upper Dassan and from the Upper Ken. When these projects are advanced, a move can be made to examine the remaining great rivers of Central India.

As regards lakes and isolated storage sites, there is no doubt a wide field for enterprise and unlimited work, but progress is bound to be slow, for a large establishment is required for observation and survey. But while the preparation of new schemes is in hand, much may be done in restoring

old works, which are studded throughout the country. The causes of their failure are often due to mere neglect, but in many cases it is feared that the banks were cut with the expressed object of cultivating the rich soil in the beds of the tanks. This is a penny-wise and pound-foolish policy, as every drop of water should be conserved in Central India for the purposes of (*a*) strengthening the under-ground reservoirs; (*b*) creating dew, and reducing the aridity of the climate; and (*c*) increasing the comfort of man and beast. Moreover, the area gained by draining a tank is not so large as that which would be protected along the fringe of the water and below the embankment.

In the case of very old tanks, Mr. Sturt, late Assistant Commissioner of Jhansi, has noted that he considers their ruin to be due to the increase of flood water which now rushes down the nallahs. This increase he attributes to the denudation of the country, and he was of opinion that the same volumes did not exist in the Chaudal period, when water was jealously held up in every available spot and not allowed to accumulate into overwhelming floods.

Well irrigation is a splendid industry in Central India, but in a year of drought it is sad to see these sources of supply fail, when the crops are suffering, forcing the cultivators and their oxen to be idle. The fact is that well irrigation is not antagonistic, but is ultimately dependent on the forms of protection already dealt with, *i.e.*, field embankments, lakes and tanks, river weirs and canals. These three systems all tend to retain the water in the country and raise the spring level, which will no doubt bring back into use many an old well.

Regarding the effect of arresting the flow of rain water by the construction of lakes, it will interest readers to quote the exact words of Mr. Sturt, which were written more than thirty years ago :—" There is no questioning the fact that Bundelkhand was once a most flourishing province, supporting on its own productions a vast population, the extent of which it is now difficult to realise. There are numerous signs to prove beyond any doubt that extensive crops of sugarcane and other most valuable produce were raised in every part of the district with the help of well irrigation. Numerous old lakes, tanks, wells, and stone sugar-mills, which are found scattered about all over the district, testify to the fact, and are the monuments of the industry and science of the past ages. None but an immense community, such as we imagine the population to have been some ten centuries ago, could have undertaken the colossal works of that period, some of which still exist and defy decay. To the population and nature and extent of cultivation of that time, the existing condition of the district, and indeed the whole of Bundelkhand, can hold no comparison, and the difference is hardly credible.

Taking Jhansi as a fair sample of the best of Bundelkhand, we find the proportion of the cultivated area to the area of the whole district 47·33 per cent, producing indifferent crops of all kinds and grain in quantities which are barely sufficient even for the support of the present scanty population, the average of which before the famine of 1868 was 203 souls per square mile. The kharif crops are extending, while the rabi which are more valuable, are proportionately diminishing (a certain sign of the poverty of the people), not so much from any paucity of plough cattle and cultivators, as from the loss of fertility of the soil, and loss of the means of irrigation. The former is attributable to the effect of surface drainage, and the latter to the fall of the spring levels of the country. This fact is most apparent to every one who has lived in these parts and studied the subject. According to my idea the evils described above may be considered as the principal causes which have led to the present reduced state of cultivation and poverty of the cultivating classes. And, as said before, these evils are the common result of the rapid flow and the scouring action of the surface drainage which, unchecked by artificial means, has worked its full destruction on the soil. On this point Colonel Corbett, after giving the proportion of the mineral particles contained in the rain water states regarding the *deterioration of the soil* :—" Hence the benefit of allowing rain to penetrate instead of allowing it to run off the surface, as in the latter case these mineral matters are lost to the soil, and not only are these lost, but also organic matters of all descriptions there may be on the surface ; the minuter particles of the soil, for instance clay and lime, are washed out from between the coarser particles, which are mostly silicious sand. Thus the high land remains mere sandy soil." Colonel Corbett's experience, however, was that of the level countries of Rohilkhand and Oudh. If then, we find the wasting process of surface drainage so great in those parts, what must be its effects on undulating country like that of Bundelkhand ? Many instances exist in which the land, which at the settlement had been recorded as *mar* and good class of *parwa*, has now turned into *rakar* and *patro* respectively ; and the cause of this is clearly traceable to the influence of 'nallahs' and ravines subsequently formed, or increased in dimension since the settlement. Instances of the converse conditions also are present, in which the land has improved and changed from the inferior to the superior description, by damming up of streams and building up embankments round fields. Old temples, mosques, graves, wells and the like, built out in the open, show in a marked way the extent of wastage which has taken place on the surface of the ground ; the very foundations of the old buildings are now exposed. The formations of the ravines are in

themselves a convincing proof of this phenomenon, and if further facts are required, the field survey of 1835 may be compared with the lately made maps, and it will be seen that the most startling changes have occurred in the loss of culturable land and extension of barren plains and ravines. The culturable area decreases as the ravines and rivulets extend, which they are constantly doing, towards the watershed of the country, converting the fertile soil into sandy waste or gravelly barren land—the residue of the over-rich soil, after having had all its fertilizing particles washed out of it by the action of surface drainage.

The loss thus incurred in the cultivated area is more serious than any damage caused by saline efflorescence in the Duab, as the latter is temporary and remediable in course of time, but the former is almost irrecoverable and permanent after it has once reached a certain stage. Under the circumstances the matter deserves the most grave and serious consideration of Government with the object of introducing measures for the prevention of further loss, if not for the restoration of part of the land destroyed by the causes described.

With the results of surface drainage above described before us, it is not surprising that the fertility of the Bundelkhand soil has deteriorated, and that the spring levels have fallen to a depth at which irrigation is rendered almost impossible.

In regard to *lake irrigation*, it seems that none of the old lakes are provided with any extensive irrigation works, and it appears that irrigation from lakes was limited to the marginal land which was effected by the system of lifts or *dal*, and to the land lying below the lake, supplied with water by percolation. It is, therefore, clear that the lakes were not constructed for the primary purposes of direct irrigation, but that the constructors had in view the more important object, which now-a-days is designated " indirect benefit," that is, the raising and keeping up of spring levels, equalizing the temperature by supplying humidity to the atmosphere, and providing pasture for cattle, etc., and no doubt these are the principal objects for which lakes should be constructed.

Irrigation from wells was certainly the principal mode of irrigation practised in the ancient times, and it is my firm belief that it is even now the only practicable system, and by the general introduction of which the country would derive a permanent benefit. That this loss of the means of irrigation throughout the country is due to the fall of spring levels is unquestionable. The existence of stone-mills, wells and other irrigation works proves the use of irrigation at the places where they stand, but now in these places the spring level has gone down to 100 feet below the surface,

and thus land has deteriorated into an unculturable waste. There must of course be many theories to account for this; and different ones must be suitable to different parts of the country. For this Bundelkhand province, I not only agree in considering the rapid drainage of rain water from the surface of the ground, as one of the causes which have affected the spring levels of the country, but from observations made in the course of twenty years' experience in these parts, I am quite convinced that it is the principal, if not the sole, cause of the phenomenon in question. The reverse conditions are also to be found wherever water is stored or by the nature of the soil allowed to be absorbed into the ground; there the spring levels are found to lie close to the surface. The spring levels in the wells at Magarpur, Jawan Sakrar and many other neighbouring villages, are kept up close to the surface by the percolating influence of the Arjar lake. Fruit and timber trees of all kinds thrive and grow to an immense size along its course, and ploughing is rendered easier there. The same may be said of all villages situated in the vicinity of other lakes. The construction of the Pachwara lake has had the effect of raising the spring level of wells all round it for several miles, as shown by the registers kept up by the Irrigation Department. All these facts, I trust, go to prove that I have not based my convictions on mere hypothesis.

There is one more method of improving the conditions of Central India which I should like to mention before closing this article, and that is the improvement of communications. A good deal has been done already in opening railways and main roads, but the feeder lines of communications are very difficult, which prevent people from getting their produce to market and moving about the country. There is no possibility of finding funds to make these minor roads anything better than fair weather lines, but communications would be greatly improved if the available money was steadily spent at the difficult points, *i.e.*, in easing the descents into *nallahs* and ascents over passes. Over the rest of the roads nothing is required except the removal of rocks or obstructions, and no money should be ever laid out in raising tracks unless there is every promise of metalling them in the near future.

SOME DISEASES OF PALMS.

By E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist, Agricultural Research Institute, Pusa.

FUNGUS diseases of palms are rare, a fortunate matter if we consider the extraordinary value of these trees to the people of tropical countries. A few have appeared in India in recent years, each apparently confined to a particular part of the country and, while due to different causes, agreeing in their general effects.

KOLE ROGA DISEASE OF BETEL PALMS.

A disease of betel-nut palms (*Areca Catechu*) has been known in the Malnad districts of Mysore particularly near Koppa for many years. It is locally termed "kole roga" or black rot. Up to the present it has not been found elsewhere and, as it does not appear to have extended much during the time it has been observed, it is probably favoured by the special climatic conditions of the locality where it occurs.

The first symptom of the disease appears at the time of flowering. A number of the flowers fall without setting fruits, and their stalks blacken and putrify. The rot gradually extends along the inflorescence and affects the stalks on which nuts are forming, causing the latter to drop while immature. Very often the damage does not stop here. The flower stalk arises from the axil of the lowest leaf and, therefore, leads directly to the base of the swollen green part at the top of the stem. This green portion consists of a number of leaf sheaths, which clasp the young growing end of the palm, forming a thick protective covering to the growing point. The lowest of these sheaths becomes affected near the point of origin of the flower stalk, and a patch of rot makes its appearance at this point. The sheaths next underlying the first are then attacked and, since the internal parts are softer than those outside, the rot spreads with increasing rapidity as it approaches the apical bud. When the growing point in the centre of the bud is reached, it also is destroyed, and the whole head withers and falls off. Not alone therefore

is the crop lost, but the whole tree is killed, the damage caused in the affected districts being very heavy.

In the disease spots on the leaf sheaths and also on the withered fruit stalks, a fungus of the genus *Phytophthora* is found. There is little doubt that this is the cause of the disease. The few species of *Phytophthora* are all virulent parasites, and though the well-known *Phytophthora infestans*, the cause of the potato disease, has been grown on dead substances, its development is much less vigorous than on its living host. The betel palm *Phytophthora* is evidently, from its position, anatomical characters and the enormous quantity of spores which it produces, an active parasite.

The fungus consists of a mycelium or vegetative part living within the tissues of the palm and extending out on to the surface, and of sporangia or reproductive bodies formed exclusively on the external filaments of the mycelium. The internal part consists of colourless threads lying between the cells. Here and there these filaments reach the surface and grow out into short branched threads. At the ends of these, and also sometimes on short stalks set laterally, the sporangia are produced. They are pear-shaped bodies with the broad end attached to the stalk, from which they fall easily. In water they germinate rapidly, giving rise each to a dozen or more tiny swimming spores, the zoospores. These swim off in all directions and after a time come to rest, get quite round and in their turn germinate by putting out a thread. It is by means of these sporangia and zoospores that the disease is propagated.

Since for their proper germination *Phytophthora* sporangia require to fall into water, most if not all the diseases due to these fungi are closely dependent on conditions of moisture and rainfall. For the spread of the betel-nut disease, which appears to begin on the flower and fruit stalks, it is necessary that the moisture conditions should be favourable during the time of setting of the fruit. The heavy monsoon rains in these parts of Mysore begin in June and last until the end of August or September. The following observations may serve to explain the increase in severity of the disease in recent years, and also its restriction to a single area.

When the disease first made its appearance, some thirty or forty years ago, it was customary to harvest the nuts in November or December. For the last twenty years the harvest has become earlier, being sometimes collected as soon as July or August. This indicates a change in the habit of the tree, due either to a different method of treatment or the introduction of an earlier variety. The effect of this is to expose the fruit stalks to infection at a time when the moisture conditions are most favourable for its growth. In some gardens the harvest is still gathered in December, and in

these I was informed that there is little complaint of loss from the disease. In Mudigere and adjoining parts of Mysore the harvest is ordinarily in December and January, and the disease does not appear to have obtained a hold in this district. Similarly, though the whole of the country approaching the ghats obtains a very heavy rainfall, the harvest is later than at Koppa in most places, and here also I was informed disease does not appear. The cultivators themselves are aware of the deleterious effects of rainfall during the maturation of the nuts. At Koppa they have devised a remarkable method of protecting the bunches during the monsoon. Before the commencement of the rains each bunch is covered with a thatch made of the leaves or expanded flower stalks of the palm. It is stated that considerable benefit has resulted from this practice.

In endeavouring to check the disease, two objects should be aimed at. The first is to revert, if possible, to the late harvested crop of former years. This may be possible by altering the methods of cultivation now in use in the betel gardens. To ascertain if this is possible, a much fuller inquiry is necessary than I was able to undertake. It may be that by a less forcing treatment—the palms are in many places trenched to a depth of six inches, the trench filled with cattle manure, and a mulch of leaves, new soil, etc., applied round their bases—a later crop would be obtained. Experiments are necessary to settle this point and also the degree to which it will be really effective in preventing the spread of the disease. Search should also be made for later varieties of betel palm, if such exist.

The other and more efficient method of prevention is the improvement of the covers used for the bunches. The covers now in use are far from satisfactory. They dry and crack in fine weather, and during long continued rain rot and fall to pieces. They are tied over the bunches as soon as the rains begin, and no disadvantage appears to result from the shade which they cause. But leaky covers are likely to be worse than none at all, for they check evaporation and ventilation, and preserve a moist atmosphere around the bunches which is bound to favour the growth of the fungus. The use of tin covers would, I believe, not be beyond the means of the well-to-do owners of gardens, and would be far more effective than the palm ones. An educated native of Koppa informed me that he had made experiments with zinc covers with very good results, the covered nuts remaining quite sound while those uncovered rotted. The tin covers would last for several years and, if made on a sufficiently large scale, would not cost a sum beyond the reach of the ordinary betel grower, and would repay their cost in a single year in all probability. It is well worth while endeavouring to introduce the use of these tin covers in the affected districts as a substitute for the leaf ones.

BETEL NUT PLAGUE IN SYLHET.

The cultivation of the betel palm is one of the chief industries of many tracts in Sylhet, and a serious disease would be expected to attract a considerable amount of attention. It is, however, a curious instance of the fatalism which is such a bar in India to the application of certain sorts of scientific agricultural practice, that the disease here mentioned should scarcely have been heard of until a couple of years ago. As a matter of fact, enormous number of palms are dying over a large extent of country, and the cultivators themselves are in a state of passive despair in face of a calamity which they cannot understand.

The extent of the area affected is quite unknown, but it includes almost if not quite the whole of North Sylhet. I have seen the disease from Chhatak to Badarpur in greater or less severity, but there are centres where the loss is very much more serious than elsewhere. One of these is Kanairghat which I visited in May 1905. In Kanairghat and the surrounding villages there are hundreds of acres of betel gardens, and the actual loss suffered amounts in many cases to more than seventy-five rupees an acre annually, while some gardens were seen in which fifteen-sixteenths of the trees had been killed.

The symptoms are quite characteristic and are readily recognised by the villagers. As in the Mysore disease, one of the earliest signs is a dropping of the nuts. Almost the whole produce of the palm may be lost in this way at an early stage in the disease. Very soon the swollen green part at the top of the stem, below the leafy head, is found to be diminishing in size, and quite the most striking symptom is this change from the graceful curved swelling of the coverings of the terminal bud to an almost straight-sided cone at the top of the tree. Withering of the outer leaves accompanies this change, leaf after leaf withering until the whole head dries up and falls off. The final appearance is just the same as in "kole roga."

In the early stages of the disease the leaves and terminal bud show no signs of rotting, and even after the outer leaves begin to wither and the head to shrink, the conditions resemble those which would be caused by drought or some general disturbance, and not by a local disease at the crown of the palm. No trace of any parasite fungus can be found in the earlier stages at the top of the tree. The stem is generally healthy. Below ground, however, matters are different. Here there is invariably a rot, either of the roots or of the below-ground part of the stem, even in very early cases. A large number of trees of all ages were dug out and examined, with the result that the presence of a root disease was placed beyond doubt. In some cases the base of the stem itself remained healthy,

while all or most of the feeding roots were destroyed. In others the rot was more visible in the stem. The characters of the rot were similar in all cases, the wood being turned brown and filled with the mycelium of a fungus. Usually this fungus was found to have invaded the ends of the roots and to have progressed along these into the stem, killing the tissues as it advanced. But whether it originates in the roots or appears first in the tissues of the "collar," the effects are always the same and are quite sufficient to account for the death of the trees.

A number of root-destroying fungi are known in different parts of the world. In most cases their attack is more or less similar to the above. The Himalayan deodar disease, due to *Fomes annosus*, attacks at first the lateral roots and works its way into the stem, where it sets up a destructive rot, eventually killing the tree. Similarly the Rosellinias, of which several different species are responsible for the disease known as "stump rot", which is so common in tea and coffee estates, act in much the same manner. In all, from the position of the attack, remedial measures are extremely difficult, though the fungus may be prevented if taken in time from spreading to adjoining trees. The case which has been most fully tested is "stump rot." Several outbreaks of this have been checked on the writer's recommendation by trenches carried round the diseased patch in the earlier stages. The trenches were about two feet deep and a foot broad and were carried well outside the ground which the diseased roots might be expected to occupy. The trees inside the trench were pulled up and burnt, the ground being levelled and allowed to remain fallow for over a year. No new cases occurred outside the trench, though where this treatment is not adopted the diseased patch continues to expand almost indefinitely. Similar results have been obtained in Ceylon and elsewhere.

The following observation suggests that the same treatment may be successful in checking the betel-palm root disease. In a village near Kanairghat, I visited a very large garden in which over fifty per cent. of the palms were dead or dying. One corner of this was found almost entirely free from the disease. This was separated from the rest by a ditch which cut off sharply the diseased from the healthy portion. Everything appeared to indicate that the salvation of this part of the garden was due to the presence of the ditch.

To be effective, trenching must be undertaken as soon as the first disease appears in a garden. The trench should be two feet deep, about a foot broad and drained so as to prevent water accumulating in it. It should entirely surround and cut off the first affected palms. It is unusual for the whole of a garden to be attacked simultaneously. Generally one or a few trees are

first affected, the disease spreading from these. Though it is probable that a part of the spreading is due to spores, infected soil or something of the sort being conveyed through the air or on the feet of the cultivators, the main infection occurs through the ground. Very few known fungi travel through the subsoil, most living in the upper layers and, where parasitic, attacking the superficial roots only. Hence a gap in the soil two feet deep is amply sufficient to stop this progress. But while the mycelium cannot gain across through the air, it probably can through stagnant water and certainly through dead leaves or debris, should any be allowed to lie in the trench. Hence it is absolutely necessary to keep the latter clean and to drain off any standing water which may lodge in it. Should it be desired to utilise the ground inside the trench for replanting at an early period, the diseased palms should be cut down and their roots dug out and the ground turned over at frequent intervals for a year. This by itself is frequently sufficient to destroy the last traces of a parasitic fungus in the soil, but the process may often be shortened by adding lime. When the palms have been removed, a crop of plantains or other garden produce can be immediately grown with safety, as the disease does not spread to any of the common crops seen. After a year, if treated as above, betel palms may be transplanted to the infected place and will probably escape attack.

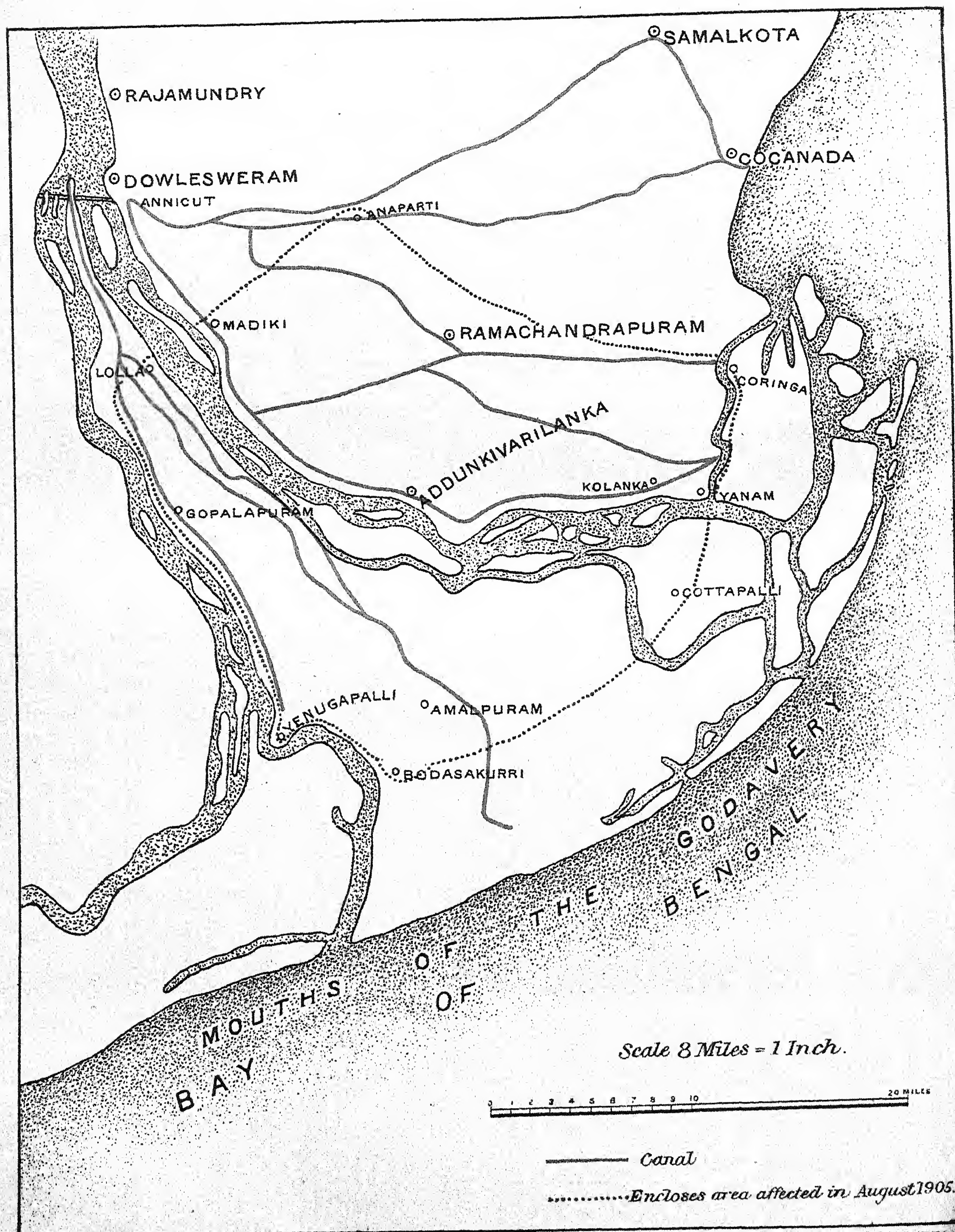
As regards the identity of the fungus, little can be said. From the presence of what are known as "clamp-connections" in the mycelium, it is probably one of the "higher" fungi—toadstools, bracket fungi or their allies. One such was found very frequently on the base of the stem of dead trees and has been identified as *Fomes lucidus,* a common tropical fungus, which there is considerable reason to suspect of parasitism on trees. But it is quite impossible to speak with any degree of certainty, and the actual working out of the cause of the disease would probably occupy a mycologist for many months. Enough has been said above to make it clear that the disease is a root rot and that there is evidence of its spread chiefly through the soil; and this being so, the treatment must follow the lines above suggested, direct cure being out of the question.

Disease of Palmyra and other Palms in Godavari.

It was stated in 1904 that a disease was ravaging the palmyra palm (*Borassus flabellifer*) plantations which are such a feature of the landscape in the Godavari Delta. Next year it was reported that cocoanut palms were also being attacked, and the danger which might arise if such a disease spread to the rich palm-growing districts of South India was at once apparent.

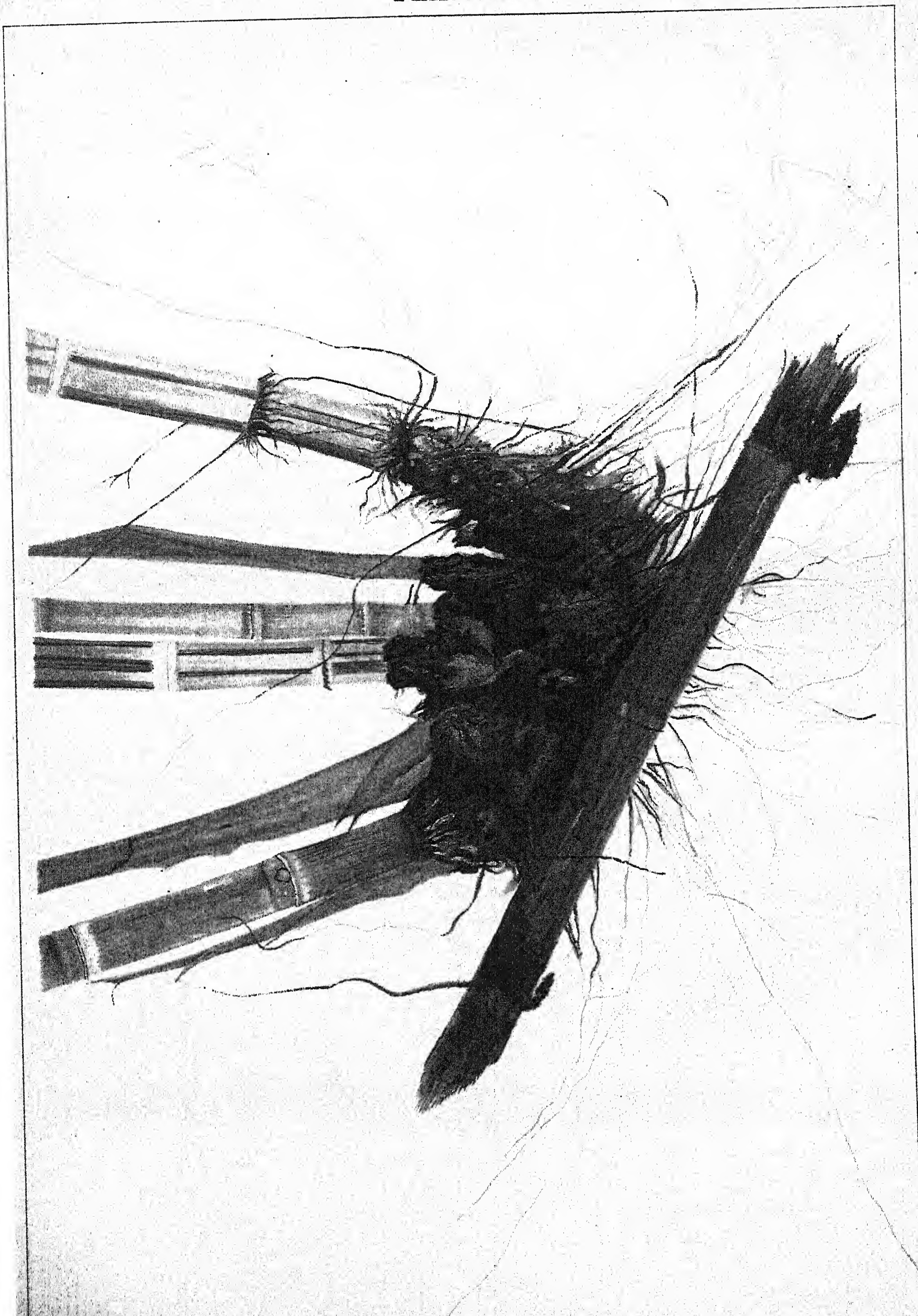
PLATE XX.

MAP SHOWING AREA AFFECTED BY PALM DISEASE IN THE GODAVERY DELTA.



LITHO. THACKER, SPINK & CO. CALCUTTA.

PLATE XIX.



West, Newman chromo.

The disease is said to have been noticed as far back as 1897. It has, however, only attracted attention by its extension within the past two or three years. It is said to have been seen first in Addunkivarilanka, an island in the north channel of the Godavari (*see* plate XX). From here it spread to the Amalpuram taluk on the southern bank and to the Ramachandrapuram taluk on the northern bank. It is now found in an area on both sides of the northern channel, occupying the whole of the Amalpuram taluk except the swampy district towards the sea, while on the Ramachandrapuram side it has reached Anaparti, about twelve miles from the river. Along the banks it extends some thirty miles, from the vicinity of the French settlement of Yanam to Madiki and Lolla. As in most other cases of infectious disease, it does not occupy an absolutely continuous area. Some villages have escaped though surrounded by diseased localities, and in some directions extension has progressed much more than in others. Thus the disease has been known at Polanka for six or eight years, and a mile or two to the east the palms are dead in great numbers; yet another mile along the canal not a single case was seen in thousands of palms visible from the banks. It may, however, be said in a general way, that in a circle from the centre at Addunkivarilanka where it is said to have started, with a radius of fourteen miles, most of the villages are affected. In the portion of the Coconada taluk towards the river, some twenty-five villages have reported the presence of the disease.

In the early period of the epidemic, the opinion was held by many of the local officials and prominent landholders that insects, particularly a large (cockchafer) grub which is common enough in diseased trees, were the cause of death. But it is certain that they have nothing to do with it, for the whole nature of the disease is opposed to such a view, and a number of trees in the early stages were examined without finding the grub. The sharp limitation of the affected locality such as is found, for instance, near Yanam and Kolanka, joined to the slow spread through an almost continuous area, shows an infection by some germ incapable of rapid transmission. Most of the persons with whom I discussed the disease had already given up the idea that it is due to insects.

The extent of the damage can only very roughly be estimated. Along the Amalpur east bank canal seventy-six per cent. of one hundred and thirty consecutively counted palms were dead. This was a very bad place. In a similar line near Kolanka thirty per cent. were dead. Elsewhere every proportion down to few or no dead trees was seen. Possibly about ten per cent. of the palmyra palms of the above mentioned area have been killed. The trees are said to be worth from one to two rupees per annum, and the loss

already sustained, though much less than that due to the Sylhet betel palm plague, must run into lakhs.

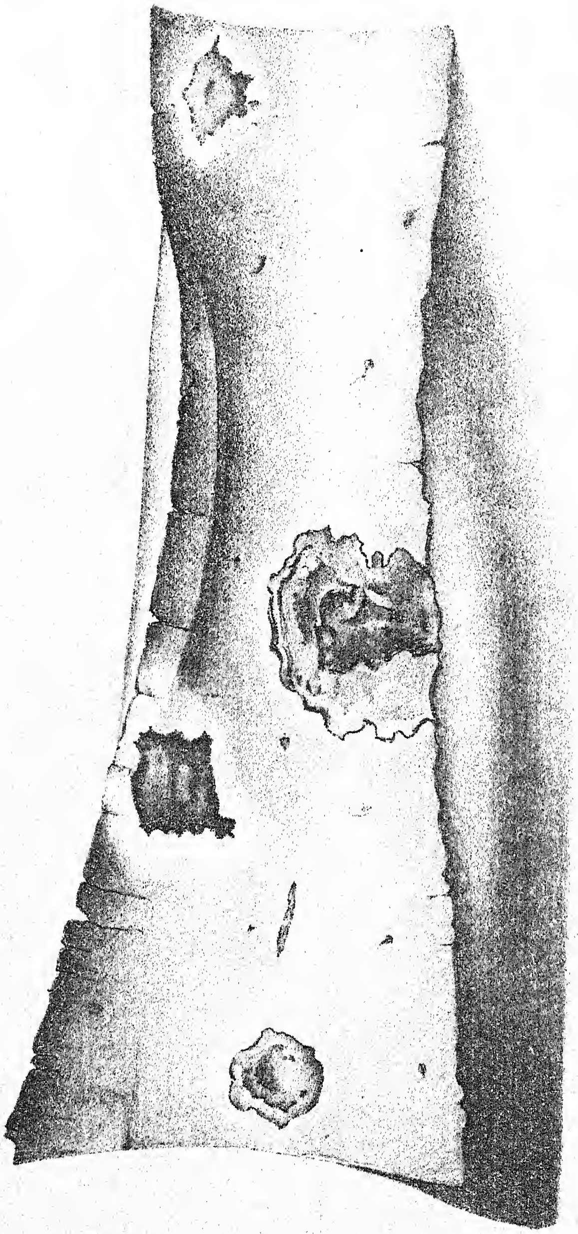
The most serious aspect of the matter is the fact that cocoanut palms are undoubtedly subject to infection. In Ramachandrapuram taluk a few cases only were seen, but in Amalpuram they are numerous, though fewer than in the palmyra. This is perhaps due to their harder tissues which oppose a barrier to infection. In one locality some two hundred dead cocoanut trees were seen ; elsewhere only a dozen or two. The danger is that the disease may increase in virulence in regard to cocoanut palms if allowed to rage unchecked, and this is the most urgent reason why prompt measures to stamp it out are called for. A few betel palms were found attacked apparently by the same disease, but the cases were too far gone for satisfactory examination.

As in the other palm diseases above described, the symptoms are such that it can be recognised fairly easily. Most of the proprietors were able to point out even the early cases, their statements being checked by cutting down a number of the palms indicated. The earliest sign is an alteration in colour of one of the leaves, usually one of those recently expanded towards the centre of the bud. This turns white and soon afterwards commences to wither. Other leaves are attacked in turn, the heart of the bud is reached, and the whole top withers and falls off, the last stage often being reached only after a considerable time. In cocoanut palms the same general course is followed, but here if the nuts have been formed before the attack becomes severe, they are often dropped prematurely. No new nuts are formed once the characteristic symptoms show. No case of absolute recovery was met with, but in one or two seen it was said that the disease had been checked for a time and had then recommenced.

The whole of the stem and root system is perfectly healthy up to a late stage in the disease. With the crown, however, the case is otherwise. The expanded parts of the leaves are, it is true, unaltered and apparently healthy until withering sets in. In the leaf sheaths, however, the signs of disease are unmistakeable. These sheaths are a remarkable feature of the structure of most palms. They form a series of twenty or thirty tube-like layers closely applied one under another so as to form a funnel. The actual top of the stem or apical bud is sunk in the centre of this funnel and protected by it, a protection which is a necessary one, for it is the most vulnerable part of the tree and death follows its destruction. To reach the apical bud a parasite must penetrate these layers. This is what actually happens.

The leaf sheaths of all diseased trees are marked by irregular, sunken spots in greater or less number (Plate XXI). In the earlier stages, and

PLATE XXI.



LEAF SHEATH OF PALMYRA PALM
SHOWING DISEASE SPOTS.

particularly in the inner layers where young ones are often numerous, the spots are white ; later on they become brown. They are always sunken and usually have somewhat raised edges. They begin on the outer sheaths and may be traced in through succeeding ones towards the heart of the bud. As the inner layers are softer, the inside patches are often larger than those outside, and may even give rise to new patches which extend out again to the outside sheath. In all cases, however, the first appearance is on the outer sheaths. The earlier patches are dry and either free from any appearance of a parasite on the surface or covered with a white mycelial felt. Very soon a wet rot follows, which extends with great rapidity in the delicate central tissues and converts the whole heart into a foul smelling mass of putrefaction, in which everything is involved, and the original agent is lost sight of. It is at this stage that the insect grubs referred to make their appearance, possibly attracted by the smell. They are, however, of several different kinds, often absent altogether, and evidently not connected with the disease.

It is only in the early stages before the wet rot starts that the true cause can be made out. This is a fungus of the genus *Pythium*, a near ally of the *Phytophthora* found in " kole roga." In quite young spots the mycelium is found only within the leaf sheath tissues, where its threads extend between the cells, sending little branches or haustoria into them. These are the feeding organs of the fungus by means of which it absorbs the living cell substance and kills the cells. Later on it comes out on the surface, forming often a dense white felt or filaments bearing sporangia. The fungus resembles that found in " kole roga." It is, however, formed of larger threads and has a different manner of germination of the sporangia. Instead of the zoospores escaping directly from the sporangium after it falls into water, they come out in an immature condition into a thin bladder formed at its top and finish their development here. Then they escape and swim off in every direction. After they come to rest they germinate quickly by putting out a thread which can reproduce the whole fungus.

Dissemination may be brought about in several ways. Withering of the head may expose the inner sheaths where most of the spores are produced, or some of the latter may occasionally form on the outer layer especially on the secondary spots which develop from diseased patches in the inside ; in either case they would be carried about by the wind. Once the wet rot which invariably follows has appeared, this mode of spread is not likely to occur, though there is a second spore form sometimes produced, which may be capable of surviving the general putrefaction. This second spore is a sexually produced "oospore" with thick walls and germinating in a different manner to the ordinary sporangia. It belongs to a class of spore forms

whose chief function seems to be to carry on the life of the fungus plant through periods of hardship; for while the ordinary sporangia can only germinate within a few days from their time of formation, the oospores can often remain capable of germination for many months. It is quite possible that when the whole head has rotted away, these spores get blown about and germinate on a new palm. Insects also may assist in the spread, should they gain access to the sporebearing mycelium on the surface of the spots. Infection might also be carried by the knives of the toddy drawers, since each tree is climbed every year either to draw toddy or to cut the leaves. But whatever the usual mode of conveyance, it is evidently slow, and this is probably due to the fact that spore formation occurs usually between the inner layers of the bud, where they are not exposed to wind or any other of the usual modes of dissemination.

Nothing but the most energetic action is likely to avail in checking a disease of this kind. No remedial measures intended to cure trees already attacked are possible. The disease is invariably fatal, and only drastic measures directed to removing the source of infection can be relied on as being of the least use. In view of the fact that the area affected is small and that, so far, the disease is not known to exist outside the Godavari Delta, a vigorous effort is required to stamp it out before it has got beyond control.

The disease may be fought in two ways. The formation of spores may be checked by cutting off the bud from the stem as soon as the first leaf turns white. This entails little real loss except the cost of labour, for the palm is doomed once the early symptoms appear, and the flow of toddy on which the chief value of the tree depends is likely to be small during the remainder of its life. At the same time infection of healthy trees can be guarded against by brushing or spraying the outside of the bud below the expanded leaves with a fungicide.

The following suggestions are made for an organised campaign against the disease. A special staff is required, for it is certain that, at first at least, the villagers will be slow to take measures for their own protection. If, however, the results bear out the value of the work, real co-operation may be expected before long. A number of expert palm climbers (such as toddy drawers) should be selected under the charge of an agricultural inspector or some similar official and provided with small axes or saws. They should be instructed to climb all diseased trees, both those in the early stages and those already dead, and to cut off the green tops below the swelling of the leaf sheaths. It is particularly essential that all trees in the early stages should be dealt with, and these can be recognized, where the villagers themselves are unable to do so, by the whitening of one of the leaves towards the centre

of the head. After cutting off the heads, the whole of the tops should be collected into a heap in each village and burned. In this way every dead or attacked palm in a selected area would have its power of spreading infection destroyed by burning the diseased parts, and this measure alone, if steadily pursued, is certain to give good results. The infectious matter is confined to the head of the palm and, as the tree is doomed once the disease appears and will yield little or no further profit, its removal costs little but the actual expense of labour in cutting it down and burning it.

To save healthy trees within the affected districts, in places where they are surrounded by large numbers of dead or dying trees, is difficult unless the above measures are very thoroughly carried out. But the chances of their infection may be very largely diminished if they are brushed with Bordeaux mixture on the leaf sheaths when the removal of diseased trees commences. Bordeaux mixture is a substance which adheres strongly to the surfaces of plants and, being poisonous to fungus spores, it prevents their germination or kills the young germ filaments as soon as they appear. A second gang of toddy drawers should be employed for this work and provided with small vessels containing the mixture and mops of rags for brushing it on to the sheaths. The expanded leaves need not be brushed, but only the leaf sheaths below these. One man should be able to do from 30 to 50 trees in a day, and if the work is done at the time that the trees are climbed for cutting the leaves, the cost of the labour should be small. The men employed for removing diseased trees should not be allowed to climb healthy ones, as there is some danger of their conveying the infection on their persons or axes. The cost of the materials used cannot be exactly given as it depends on the price at which copper sulphate can be landed in the district and the availability of a supply of good lime in the neighbourhood. A pint would probably be nearly enough to treat one tree, and this should not cost more than about one pie.

To prepare 50 gallons of the mixture, weigh out 6 lbs. copper sulphate, break to powder and dissolve in 25 gallons of cold water by suspending in a piece of gunny sacking in the water. The latter must not be contained in a metal vessel but in a barrel or big earthenware pot. In another vessel weigh out 4 lbs. of fresh quicklime. Slake this gradually till it falls to powder and then add water up to 25 gallons. Allow it to cool. When cool, add to the copper sulphate solution through a sieve so as to retain any lumps. A thick bluish liquid results which on standing throws down a bluish precipitate, leaving the other part of the liquid clear. To test if fit for use, add a few drops of Ferrocyanide of Potassium to a small quantity of the clear liquid in a dish. If a brownish precipitate appears, more lime must be added till no precipitate

is given on testing. Or a clean steel knife may be dipped in it and if more lime is necessary, a deposit of copper will form on the knife. If none is formed, it is ready for use. Stir well before using.

Similar remedies have been advocated for a cocoanut palm disease known as "bud rot," which is attracting much attention in Cuba and the West Indies at the present time. This disease has many points of similarity to the Godavari one, though different causes have been provisionally assigned for it. It has been found by Mr. Cradwick in Jamaica that spraying the trees with Bordeaux mixture when they show the first sign of disease has been effectual, and it is hoped, in Jamaica at all events, that with the use of Bordeaux mixture the disease may be kept in hand. Mr. Busck of the Division of Entomology of the U. S. Department of Agriculture, who investigated the disease in Cuba in 1901, believes it to be a fungal one and considers that its fatal nature precludes a remedy for trees already infected and leaves only the prevention of the spread of the disease as the object for man's intervention. He recommends the cutting down and burning of the tops of the diseased palms. Dr. Erwin Smith of the same Department studied the disease in Cuba in 1904. He believes the disease to be a bacterial one but gives the same general measures for treatment. Diseased trees should be felled and the terminal bud burned or properly disinfected with sulphate of copper. Mr. Petch, Government Mycologist, Ceylon, gives an account of a cocoanut disease, which he considers identical with "bud rot," in a recent circular of the Royal Botanical Gardens, Ceylon. He also recommends the removal and burning of the tops of diseased trees.

To be effective it is absolutely necessary to have united action in carrying out the measures recommended above. It is useless for one village to remove the source of infection if diseased trees are allowed to remain in neighbouring fields to convey infection back again. But the opportunity is a rare one, for the limitation of the disease is such as to render concerted action possible, and there is at least a fair prospect of being able to stamp it out before it passes beyond control.

SOME USEFUL FOREIGN MACHINES AND IMPLEMENTS AT THE NAGPUR FARM.

By D. CLOUSTON, M.A., B.SC.,

Deputy Director of Agriculture, Central Provinces.

The object of tillage is to bring the soil into that state of tilth best suited for the crops to be grown thereon. By tillage the surface soil is pulverised and brought into an open porous state. In Europe and America, the tillage implements stir the soil to a depth of about seven inches at least once in the rotation. In Berar and parts of the Central Provinces, where the *bakhar* (harrow or scarifier) is the implement mostly used, the average depth of cultivation is not more than four inches. This method of tillage, practised year after year, tends to give rise to a hard close-grained soil immediately below the four inches of loose soil produced by the *bakhar*. But for the fact that our black cotton soil cracks in an extraordinary manner in the dry season, this shallow cultivation would undoubtedly be more mischievous than it is in producing poor returns. That the crop returns obtained by this practice are lower than they would be after deeper cultivation with foreign ploughs, I shall prove later from results obtained on the Nagpur Experimental Farm. The hard close-grained condition of bottom soil, which the *bakhar* tends to produce, is liable to give rise to water-logging in low-lying districts in the rainy season, and to excessive drought when the dry weather sets in. Water, it is true, will rise higher in such a soil than in one of a looser texture produced by deeper tillage, but this advantage is more than counterbalanced by the fact that it rises much more slowly and therefore fails to supply the roots of the crop with the necessary amount of moisture when excessive surface evaporation is going on. Deeper tillage also gives the plant a greater root range, thereby enabling it to obtain food and moisture from depths never reached by its shallower rooted neighbour. Shallow cultivation tends to produce shallow-rooted plants which are less able than deep-rooted ones to withstand conditions of drought.

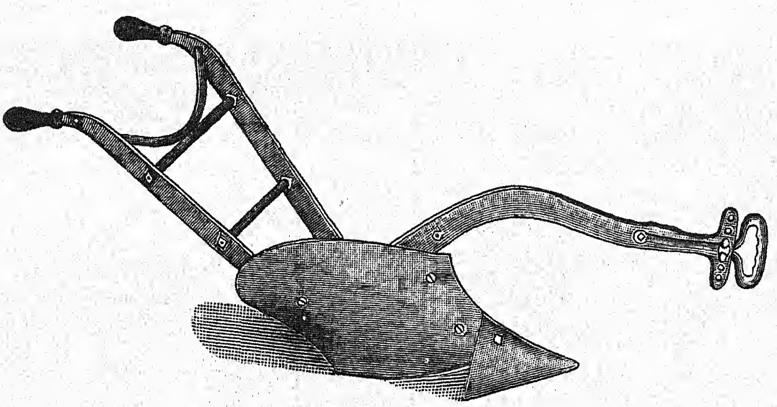
The native plough on the other hand stirs the soil to a fair depth—about seven inches on an average. Its great defect for black cotton soil lies in the fact that ridges are left untouched between successive furrows. When the same land is cross-ploughed, these ridges are broken up into big square blocks which, owing to the sticky nature of the soil and to the small amount of after-cultivation practised, are never reduced to a fine tilth, but lie on the surface seriously checking the growth of the sprouting crop. I have noticed this particularly in the wheat tract of the Nerbudda valley, though here the soil is more of an alluvial nature. It has been pointed out to me that the cultivator there prefers this rough cloddy surface, because it enables the soil to conserve its moisture in time of drought. Both these defects in the tillage of the soil are removed by the use of any good foreign plough. Those found most suitable for black cotton soil in the Central Provinces are the Swedish plough, and Ransomes' Turn-wrest plough.

To introduce foreign implements into India merely because they have been found to work well in the West would be a decided mistake. Many mistakes of this kind have been committed from time to time both by European and Indian agricultural officials. The former, not being sufficiently acquainted with the needs and practices of the Indian cultivator, have from time to time tried foreign implements which, though recognised as excellent in every way for Western conditions, proved to be quite unsuitable for the needs of India ; while the latter, relying often on a picture acquaintance with foreign machinery and implements, have again and again introduced others that proved absolutely useless. The visitor to some of our Experimental Farms will find an incongruous assortment of machinery and implements—the up-to-date reaping machine and improved iron plough of the West side by side with the primitive reaping hook and wooden plough of the East. There he will see (I) native implements cheap and simple that have stood the test of centuries, and are still recognized as being excellently adapted to the conditions of this country ; (II) foreign implements that have been found to do their work so quickly and efficiently that their extra cost is more than covered by their all-round superiority to the native implement ; (III) foreign implements, which after a trial in India have been condemned, and which only serve as a warning to over-zealous officials whose special hobby is experiments with foreign machinery.

If we are to gain the confidence of the Indian cultivator, it is clearly our duty to recommend only such foreign implements as have been thoroughly tested and have proved satisfactory on our Experimental Farms. The ryot, though conservative, is prepared to adopt such improvements as can be proved to pay. To meet the requirements of the average cultivator, the initial cost

of the implement should be as low as possible, it should be more efficient than the native implement which it is to replace, and it should be of a kind that is easily and cheaply repaired. A sensible ryot will naturally shake his head, if asked to purchase any elaborate implement or machine which he cannot afford to buy and which the combined mechanical skill of his village could not mend for him, should it once go out of order.

The objection raised by Indian cultivators to the use of foreign ploughs generally has been admirably summed up in the words "they are too dear for their pockets, too heavy for their cattle and cannot be repaired by local labour." Of all foreign implements sold at the Nagpur Experimental Farm, none has given greater satisfaction than the Swedish plough, against which none of these objections can be raised. The original Swedish plough shown below is an all-iron plough imported from Sweden at a cost of Rs. 25.

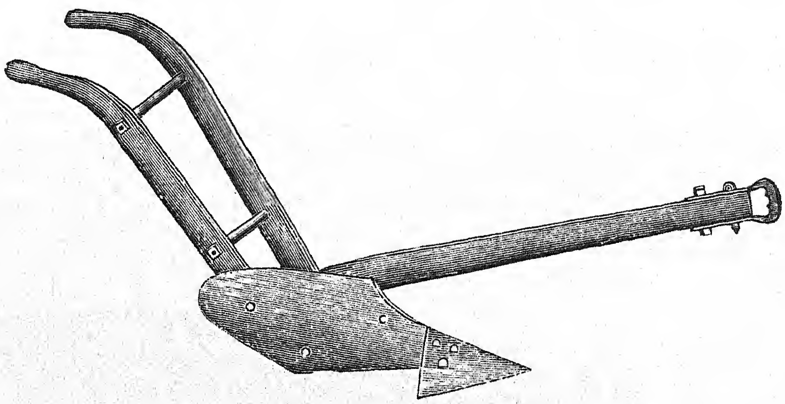


THE ORIGINAL SWEDISH PLOUGH.

The implement now sold at the Farm under that name is one that is made in Nagpur by a native mechanic. The body is formed on the pattern of the original Swedish plough ; the beam and stilts are made of wood. For making the iron parts, all that is required is a piece of angle iron cut to the proper length to form the sole, and a piece of ordinary wrought sheet iron $\frac{1}{8}$th of an inch in thickness from which both share and mould board are made. The maker has a wooden mould made from the pattern of the original plough, and on it he shapes his wrought-iron mould board. The share is made from the same sheet iron, the thicker part being made by doubling in the edge on itself.

The share is the one part of the present plough that requires improvement. Instead of having a removable share held in its place by the iron point of the breast which fits tightly into its socket, the maker rivets on

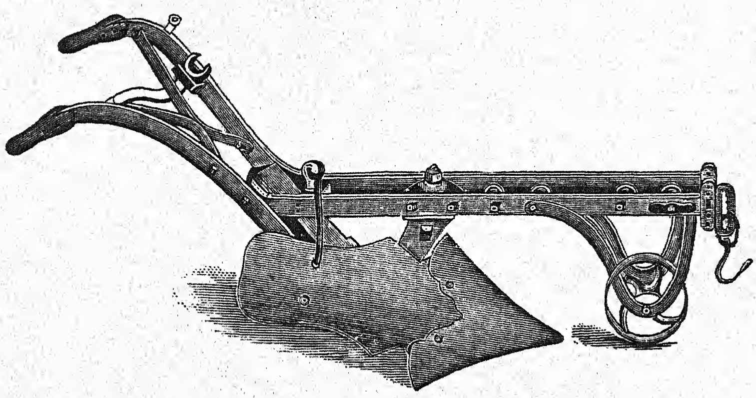
the share to an extension of the mould board. There are two objections to this—(1) the heads of the rivets are left projecting above the surface of the share, thus causing resistance when the plough is drawn through the soil; and (2) there is a great deal of unnecessary trouble in fixing and unfixing



THE NAGPUR SWEDISH PLOUGH.

such a share. Overlooking these deficiencies the plough has, in a marked degree, the good qualities ordinarily desirable for a plough in the Central Provinces. It is cheap, the initial cost being only Rs. 16; it works both in wet and in dry land; it is light and easy of draught. Two ordinary bullocks easily plough from two-thirds to three-fourths of an acre of arable land with it in eight hours. When land which has been out of cultivation for some time is to be broken up, stronger bullocks are required, and a much smaller area can be got over. It both inverts and pulverises the soil, and one ploughing only is necessary if followed by the usual harrowing. It is a very useful plough for breaking up waste land. At the Hoshangabad Experimental Farm a plot in an area which had long been overrun with *Kans* (*Saccharum spontaneum*) grass was broken up last year by the Swedish plough, and gave a yield of 280lbs. of gram. We recommend the Swedish plough to the Central Provinces cultivator of black soil as being a very cheap and useful implement. A skilful village smith should be able to renew the parts as they get worn out, or even make a new plough if necessary. The plough has now been long in use in the Central Provinces, and still continues to maintain its reputation as a first class implement both for arable cultivation and for breaking up and reclaiming waste land of all kinds. Twelve of these ploughs were sold by the Department this year.

Ransome's Turnwrest plough is another implement that has found favour both on our Experimental Farms and among the better class of cultivators who have tried it. At the Raipur Farm it has given entire satisfaction in breaking up waste land at the rate of one-fifth of an acre per day of eight hours during the dry season. It is very strongly recommended for areas infested with *Kans* grass. Such land can be broken up during the time of the winter showers. If well stirred by the *bakhar* during the dry season which follows, the roots will die from exposure to the drought and the heat of the sun. This plough is a very strong and durable implement, the parts being all iron or cast steel. For well-to-do cultivators its price (Rs. 40) is not prohibitive. The only part that is likely to require much repair is the share which is made of the best cast steel. The depth and breadth of furrow are regulated by adjustment of the bridle and wheel respectively. The plough is suitable for any depth of tilth up to ten inches. Where green-soiling is practised, an implement of this type is invaluable for making deep furrows in which to cover in this bulky manure. The fact that the mould board of this plough can be worked on either side, and that the bullocks can therefore go and return again by the same furrow, should recommend itself to Indian cultivators, whose bullocks are trained to work along only one side.



ENGLISH TURNWREST PLOUGH.

We recommend these two foreign ploughs to all cultivators of black soil, who have difficulty in getting their fields for rabi crops tilled during the breaks in the rains. As the work can be done more quickly by them, they enable the cultivator to take advantage of seasonable opportunities.

The cost of working as compared with that of the native plough has been ascertained by experiment on the Nagpur Farm, and is given below :—

Kind of plough.	Cost at Nagpur.	No. of ploughings necessary.	Labour employed.	Time taken per acre.	Cost per acre.
	Rs.			Hours.	Rs. A. P.
Swedish plough	16	One	One pair of bullocks and one man.	11-51	1 3 2
Country plough	6	Two	Ditto	26-32	2 11 10

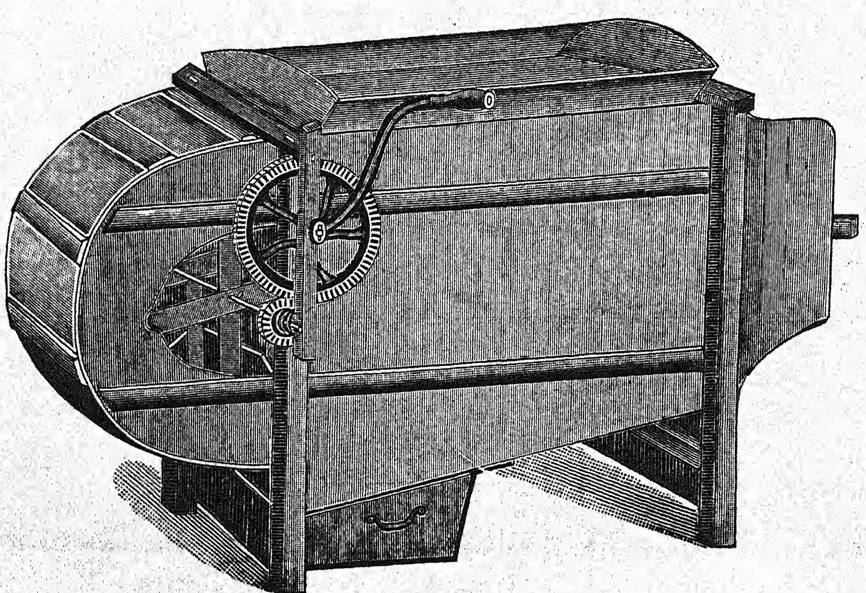
To plough and cross-plough, the country plough took more than twice the time required by the Swedish plough, and the cost of doing the work is proportionately higher. Against this must be put the higher initial cost of the Swedish plough and the greater cost of repair, but the latter can be done locally and amounts to only a small item.

In practice it is found that these foreign ploughs can be used very economically not only from the point of view of the saving of time, but also from the better crop-returns obtained after their use. An experiment was initiated at the Nagpur Farm in 1900 to compare the use of the Swedish plough with that of the country plough and *bakhar*. Three plots (·25 acre each) were chosen and treated as shown in the statement given below.

	Plot I. Bakhared (scarified) every year.		Plot II. Ploughed once with country plough and scarified.		Plot III. Ploughed with Swedish plough and scarified.	
	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
Average 5 years 1900-1905 ...	583	768	655	841	712	997
Average percentage gain on Plot I ...	...	..	12%	9%	22%	29%
Gain in value on Plot I ...	...		Rs. 2/13/10		Rs. 5/8/11	

Another implement for which there is a gradually increasing demand in these Provinces is Harder's Winnower, which is one of the best machines in the market at the present time for cleaning grain of all kinds. Its mechanism is very simple. There are two toothed wheels of which the larger is turned by means of a handle ; the smaller is attached to the end of the axle of the

wooden fanners or "blowers". The quick revolution of these blowers produces a draught which acts on the seed as it trickles down through the slot of the hopper on to riddles or sieves beneath. The chaff and dust are blown out behind the machine. The heavier grain, on passing through the holes of the riddles, falls underneath the machine, while all extraneous matter such as lumps of earth, bits of straw, &c., which are too large for the holes are shaken out over the ends of the riddles and fall among the chaff. If only the very best grain is wanted, then a larger proportion of the lighter seed can be got rid of by increasing the draught, *i.e.*, by increasing the speed of turning. Winnowing thus comes to be a sorting process. Each machine is supplied with riddles which vary in the size of the meshes so as to be suitable for grain of different sizes. The amount of shake given to these riddles is regulated by two cranks with a connecting rod. The one, a disc crank, is attached to the axle of the fanners; the other, a lever crank, is connected with the riddles. You can diminish the distance through which the connecting rod works by fitting it into an inner hole of either crank. This reduces the circumference of the disc crank, and the swing of the lever crank. The riddles thereby get a shorter and slower shake. The smaller the grain, the shorter and slower is the shake required. This winnower is figured below.



HARDER'S WINNOWER.

The number of riddles supplied with each machine is generally seven. Only three of these are used at a time. These riddles are numbered

according to their size of mesh. Though the combinations necessarily vary for different kinds of grain, still the principle on which the selection of riddles is made is the same for all. The top riddle is one of a big mesh which eliminates only bits of straw, unthreshed pods or ears, and other bulky matter. The second or mid riddle, with a continuous draught blowing over it, allows only the valuable part of the grain to pass through it. The third or lower riddle accounts for the dust only. The dust on passing through collects into the box at the bottom of the winnower.

Another point that is not always understood is how to regulate the draught. Grain on being put through the winnower for the first time generally contains a high percentage of chaff and dirt, and therefore requires a proportionately strong draught. This draught can be made greater by increasing the speed of turning, or by admitting more air to the fanners by sliding back the side doors. In dealing with a grain of small size such as sessamum, or in winnowing a larger sized one, such as wheat, a second time, we would both diminish the speed of turning and partly close these sliding doors.

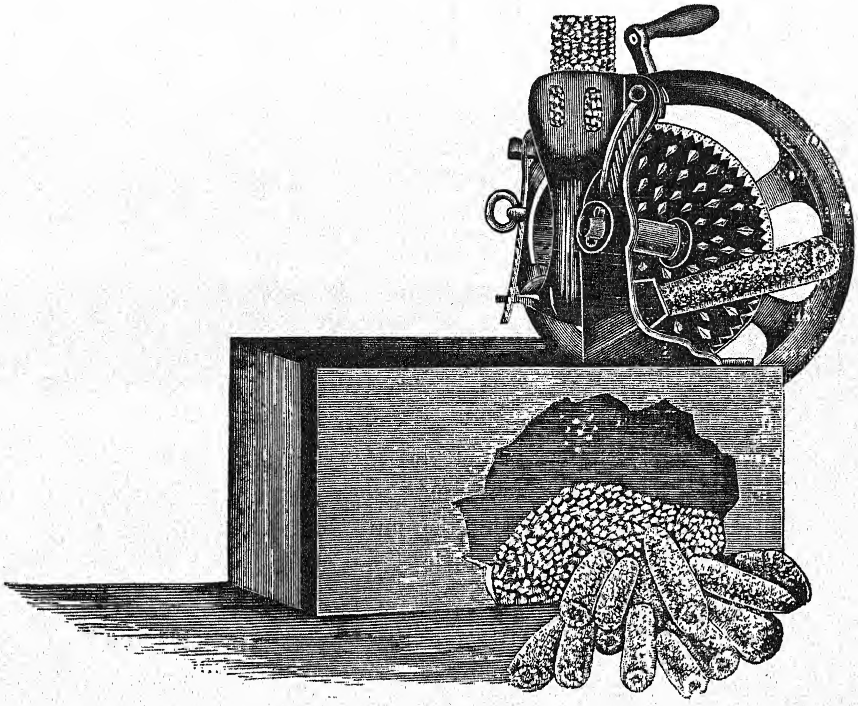
To become popular among Indian cultivators this splendid machine only requires to be known. The farmer, who waits for the uncertain winds that will enable him to practise native methods of cleaning his grain, has often to leave it long exposed on his threshing floor, and frequently suffers grievous loss from the damage done to his grain by untimely showers of rain. During the last season our cultivators have suffered much loss in this way. Tests have been carried out to compare the amount of work done by this machine with that done by the ordinary country method of cleaning grain. The outturns in pounds per day of eight hours are given below. Four men were employed in each case.

Name of crop.	Outturn by common country method.	Outturn by Winnower.
Rice and small millet	9,135	17,080
Wheat	5,600	12,298
Gram	3,560	5,663

Very little labour is required for driving the winnower. A boy will do the work with ease for hours on a stretch. The price of this American-made machine in Nagpur is Rs. 112, but a stronger machine of the same pattern is now made in the Central Provinces for Rs. 90. The wooden parts are made of teak, which does not warp, so that it is a much better implement for a tropical climate than the American original. We strongly recommend this

winnower to all cultivators who want to be independent of the exigencies of the weather, and whose desire it is to send their grain to market in a clean undamaged condition. Twenty-seven of these machines have been sold from Nagpur within the last year.

The corn sheller shown below is a most useful machine for districts where maize is grown.

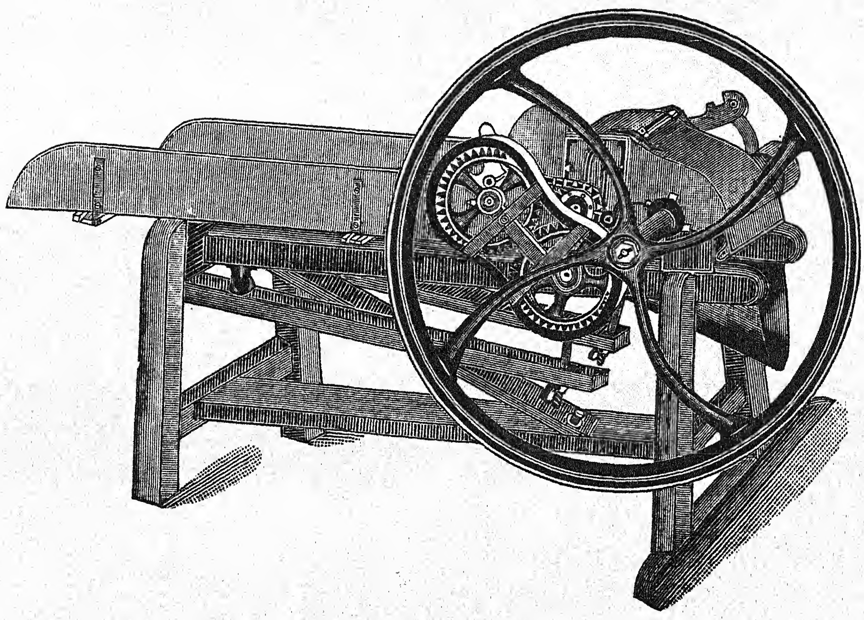


MAIZE SHELLER.

Its price is only Rs. 6-8. It consists of a wheel to which the handle is attached. On the same axle with this wheel is an iron disc with teeth projecting at right angles to its surface. The worker turns the handle with his right hand, and with the other places the cobs into the hopper. The cobs are drawn down and the seeds torn off by the revolving toothed disc. For work the machine is fixed by two nuts and screws to the corner of a box with the handle towards the outside. The seeds fall inside the box, while the shelled cobs drop down on the outside. Maize-shelling by hand is a laborious process, particularly if the cobs are at all green and tough. While with the hand one man can only shell 50 lbs. per day, with this machine he can do over 1,000 lbs. It should form part of the equipment of every holding where maize is grown in quantity.

Another machine that has come much into favour in the Central Provinces of late, is Harder's Fodder-Cutter, which may be used for fodder crops of all kinds, but which is used mostly in these provinces for sorghum. When the coarse sorghum stalks are fed to bullocks, the thick lower parts are rejected. Three-fourths of this good fodder is thus often wasted. In the Northern Districts, indeed, sorghum in this form is so little valued as a fodder, that the heads alone are harvested and the stalks are left on the ground, where they are burnt the following spring. In this way a valuable fodder is completely wasted, and an attractive breeding ground is offered to injurious insect pests, some of which harbour in these dried stems. When these sorghum stalks are finely cut with the fodder-cutter, the cattle eat up every morsel with relish ; part of it is assimilated and part of it excreted, adding to the quantity of manure available for the fields next year. The value of the ash left when the stalks are burnt on the field is insignificant. We strongly recommend this fodder-cutter for all sorghum tracts. It will enable the cultivator to use with great advantage a product of his farm, which in some tracts he has come to regard as a mere encumbrance to his land. The chief parts of this machine are the wooden trough with two ridged iron rollers at one end. These revolving in opposite directions, draw in the stalks fed from the trough. Behind the rollers are four revolving steel blades which, as they come round, cut off slice after slice of the stalk. Between the blades and the rollers, there is an iron bar which supports the stalk while the knives are doing their work. The machine can either be driven by hand or by bullock-gear. Tests carried out on the Government Farms have shown that three men can prepare 1,200 pounds of cut stalks with one of these machines in a day of eight hours, while three men and two bullocks working a round-about gear prepared 3,170 lbs. or what would be sufficient fodder for nearly 80 bullocks for a whole day. Where the making of silage is practised, the sorghum stalks can be cut after harvesting the cobs and made into ensilage. Sorghum and maize cut green as a fodder crop on the Nagpur Farm have been found to make first rate silage if treated in this way. The stalks can be cut to almost any degree of fineness. The lengths of the slices will depend on (I) the speed at which the rollers work in drawing in the stalks, and on (II) the number of knives employed. The machine is supplied with three gear wheels differing in size. The smaller the wheel employed the quicker the motion of the rollers and the shorter the slices. If on the other hand only two blades are employed, the slices will be twice as long as when all the four are working. The price of this fodder-cutter is Rs. 130. Thirty-two of these machines have been sold by our department this year.

While admitting that in recommending and advertising Western implements and machinery to the Indian cultivator, Agricultural Departments should exercise the very greatest possible amount of caution, still I believe



HARDER'S FODDER CUTTER.

that those described above have come to stay. There are others, such as Mayfurth's Thresher and Platt's Cotton Gin, that are very excellent pieces of machinery and do very satisfactory work on our Experimental Farms, but their high initial cost has so far tended to check any great demand for them.

SUGARCANE CULTIVATION IN BEHAR.

BY J. J. WILKIE.

A FEW years ago sugarcane was, to European planters, an almost unknown crop in Behar, but its cultivation is now rapidly extending. I propose in this article to give a few practical hints on the methods of cultivation best suited to Behar, which are based upon my previous experience of sugarcane cultivation in British Guiana, my knowledge of local conditions in Behar, and my trials of sugarcane in that tract, in the hope that they may be useful to the many planters who are now growing this crop. I assume, of course, that the planter who goes in for cultivating sugarcane is assured of his command of labour, and of a sufficiency of moisture in the soil.

Preparatory Tillage.—It is important that the field selected for cane should receive a thorough preparation. The soil should be carefully worked by ploughing, cross-ploughing and the like, until it is brought into a fine state of tilth, similar to that required for indigo.

Preparation of Cane Rows.—This can be done either by plough or by hand labour. In many sugar countries the cane row is made by a double mould board plough, drawn by several yoke of oxen according to the stiffness of the soil. The drills are kept approximately in line by poles which act as a guide to the ploughman, and there is no difficulty in getting the oxen to go straight when they are trained to the work. I consider, however, that the preparation of rows by hand labour, which is the method followed in British Guiana where only thick varieties of cane are grown, is preferable for Behar. In Demarara the rows are generally dug three feet across with an interval of three feet for the intervening bank. The distance must necessarily depend upon the variety of cane, but for thick varieties of cane in Behar, that most generally suitable is a $2\frac{1}{2}$ feet row and a $2\frac{1}{2}$ feet bank. It will be found convenient in aligning a field to get the largest portion possible into a right-angled figure, the offsets being set out afterwards.

After the lines are stretched from peg to peg, the coolie digs from four to six inches of earth from the row and throws it on the intervening space, so as to form a bank. The 'kodali,' the only available tool, is excellent for

this work. The earth should also be evenly distributed in order to keep the banks of uniform height.

As the earth will be dug an inch or so clear of the line, when completed there will be approximately a 2′ 3″ row and a 2′ 9″ bank. The cane rows will be exactly five feet from centre to centre. The bottom of the cane row is then forked or dug with a 'kodali,' so as to pulverize thoroughly the soil to a depth of about eight inches in the row.

Planting.—In all cane sugar countries only the three or four top joints or nodes are used for planting, the remaining portion of the cane being sent to the factory for sugar-making. Any portion of an *unripe* cane will grow provided the eyes are sound, but a very ripe cane will *not* grow except from the few top joints where the juice contains a larger proportion of water.

The methods of planting cane vary considerably in different countries. In Jamaica an iron crow-bar is sometimes used to make a hole in the ground ; in light soils this is vertical, but in heavy soils the cane-top is planted at the angle of 45°. In planting thick varieties of cane, the best method in Behar is to push the top or set into the row at an angle of about 25° till the end is flush with the ground. No ends should be left projecting above ground. Care should be taken that the eyes are at the sides and not at the top and bottom. All tops or sets should be carefully examined to see that the eyes are sound, for these are the growing points that form the shoots of the new plant, and the roots of each eye spring from the internode or ring to which the eye is attached. Great care should be taken that no blanks are left, as would be the case if the coolies were not properly supervised. A reason for planting the top at an angle is that after the young shoots spring from the eyes, they quickly reach the surface. When sufficient tops or sets are available, it is always advisable to plant a double row in the trench, the best system being that in which the end of one piece is in line with the point of the other, like this ‾ _ ‾ _ ‾ _ ‾ _ ‾ _. There is no particular objection to covering entirely the planted portions of thin varieties of cane, but the method described has been found by experience to be best for thick varieties.

The selection of tops or sets for planting purposes is a matter of great importance, upon which depends not only the vigour of the plants, but also their freedom from disease. Some useful instructions in this matter are given in the last number of the Journal (*see* page 252).

First Weeding and Covering.—When the young plants are about a foot high, the rows should be carefully weeded, and light clean earth should be drawn from the sides of the banks into the row, so as to cover the cane row to the depth of an inch or two. The intervening banks should also be

weeded, the weeds being thrown on one bank only, so as to have one clean bank and one trash bank. By trash is meant dried cane leaves and uprooted weeds. The reason for keeping both a clean and a trash bank is that they may be changed at subsequent operations, so as to ensure thorough weeding. Manure is generally applied at this stage, but this matter will be dealt with in a later paragraph.

Second Weeding and Cleaning of Canes.—When the young canes are from three to four feet high, and the larger shoots are forming joints or nodes, the bank left clean at the first weeding should be again weeded, the uprooted weeds being thrown on it. The dead weeds on the trash bank should then be thrown on this clean bank which will now become the trash bank, the old trash bank being thoroughly weeded preparatory to tilling and levelling it. All the dry leaves at the cane roots must be stripped off and thrown on the trash bank.

In dirty land it may be necessary to weed much oftener, as it is most important to keep the field free from weeds until the cane covers it. Weeds rob the cane of its plant food.

Tillage of Banks.—When the second weeding is finished, the clean bank is dug to a depth of six or eight inches below the level of the cane row, the soil being levelled. After a week or ten days, the trash should be transferred to this tilled bank, and the second bank then treated in the same manner. This work can be satisfactorily done by the flat pronged 'kodali.' It should never be done in wet weather; in fact, no cultivation should ever be done when the land is wet.

The object of the deep tillage of the banks between the cane rows is both to give the cane plants a dressing of fresh earth and also to loosen the soil of the banks, so as to allow the roots to penetrate into it. If the tender rootlet of a cane plant meets a hard bank, it gets turned back. As cane is a surface feeder, properly tilled banks between the rows are essential; badly tilled banks mean stunted canes.

Stripping or Trashing Cane.—In the rains when the cane is about six feet high and growing freely, the dead leaves may be stripped from the cane and spread upon both banks. This may be done at least once before the final stripping, care being taken not to take anything off but dry leaves.

Final Stripping before Cutting.—About a fortnight before the cane is cut, the final stripping takes place. All the dry leaves are taken off and also several of the half green and green leaves near the top, so as to get as great a length of ripe cane as possible. Probably the best time for commencing this operation is in December, the ripest fields being stripped first, and so on, so as to have a constant supply of ripe stripped cane for the

factory. In countries where cane is scientifically cultivated, stripping is usually done in wet weather. Every cane should leave the soil, free from bottom trash. There can be no hard and fast rule about stripping, and planters must be generally guided by the rainfall.

If the growth of the cabbage of a cane be checked in any way by injury, the eyes at once spring. Canes with sprung eyes are fatal to sugar-making owing to the amount of glucose which they contain, and which destroys a large amount of sucrose or crystallizable sugar in the process of manufacture.

Cutting Cane.—It is important that cane should be cut level with or slightly below the ground. This secures that the full length of the cane goes to the mill and, still more important, that the shoots from the stools for a ratoon crop will grow out of the ground, and not from the eye or eyes above ground as would be the case if any eyes were left above ground level.

The cane bill or cutlass used for cane cutting should be well sharpened, for otherwise the cane cutting will not be cleanly done, and unsatisfactory results will follow. A well sharpened 'Kodali' will perhaps in Behar be found the most satisfactory implement with which to cut the cane.

When tops are wanted for replanting purposes, the cabbage of the cane should be cut off about six inches above the first joint and the top cut off about the third or fourth joint down. The trash should all be placed on one bank and the rows left exposed to view to show that there is no cane left uncut in the field.

Drainage.—In order that surface water may run off as quickly as possible, a system of drainage should be arranged, so as to guard against inundation from heavy rainfall. A field water-logged for several days will never yield well. A drain should be dug round every field and, in lowlands, cross drains at right angles to the cane row.

Manure.—The object of every sugar-planter should surely be to obtain the maximum weight of sugarcane from the acreage under cultivation. The reasons for this are obvious; firstly, on a small area greater supervision can be exercised than on a larger area; again with the small area, more land is at the disposal of the planter, so that he can change and enrich his cane fields by the planting of rotation crops, such as indigo and other crops of the same order ; and perhaps most important of all, the small area admits of a more liberal application of manure than could be given to the larger area. If the industry is to continue, sugarcane must be manured, and the question arises, what is the best and most economical source from which the manure is to be obtained, to bring about good results which will continue ?

Oil cakes of various sorts have been used with success, but I am not sure that the supply will be equal to the demand, and the price may be out of all proportion to the manurial value. Readers of this Journal would do well to study carefully the excellent article on the subject of cane manuring by Dr. J. W. Leather, PH.D., F.I.C., in Vol. 1, Part 1. It is, of course, necessary to give careful cultivation in order to get the best results from the use of manure.

Cattle pens should be worked upon a system, so as to give the best results in both quantity and quality of manure. The following method is followed in the West India Islands by planters of long experience. The cattle pen, preferably covered over by a roof, is divided into two parts. The cattle are driven in every night and fed in the pen, a fresh bed of dried cane leaves and earth or any other convenient form of bedding being spread daily. The pen should be just large enough to contain the cattle without inconvenience. Care should be taken that no troublesome weeds or grasses are mixed with the bedding. In most sugar countries the cattle are fed on chopped cane tops moistened with molasses and water. The cattle troughs should be capable of being raised as the level of the manure in the pen rises. The pen, although divided into two, may be used as one pen until the time arrives for the manure to be taken out. When that operation is in progress, the half of the pen in which the men are working must be shut off from the other half. The railing round the pen should be strong and 7 to 8 feet high above ground level, so as to allow for the height of the manure. Professor Harrison, Government Analyst and Professor of Chemistry, and Mr. George S. Jenman, Government Botanist, British Guiana, speaking of pen manures, say : "We are of opinion that the field pen is a mistake, as the small quantities of manurial ingredients contained in the litter and fodder of the cattle are largely lost by drainage, the patches of land immediately under and in the neighbourhood of the pen alone gaining. The pen manure should be made under cover, and as little litter used as possible, the amount of earth added being only sufficient to absorb the moisture of the urine and fæces so as to give the animals a dry footing." The manure thus obtained would be richer, although not so bulky as long stable manure. It can be more cheaply applied, and will be more effective. Manure should always be applied to the cane rows and not to the whole area of the land in which the cane is planted, in which latter case the benefit of the manure partly goes to the weeds.

In British Guiana nothing but chemical manures are employed. The trash and cabbage ends of the cane are buried in the banks, when they are tilled, thus loosening the soil and allowing the roots to penetrate. It is

useless waste of money to use chemical manures on cane fields which are not thoroughly established as to cane row, well tilled, and free from weeds. The chemical manures are applied to the root of the cane, put into small holes dug for the purpose, and covered over immediately after application. The manures are applied when the young cane is from 2 to 3 feet high. It is important that cane should have an active growth in the earlier months of its career, and that such active growth should terminate in time for them to ripen before the reaping season. Young canes take up nitrogen very rapidly. Chemical manures should always be applied in moist (not wet) land and never during actual rain. A very small amount of nitrogen may be applied with advantage shortly after the cane germinates. It is best to apply the larger portion at and after the beginning of the most active period of the cane growth.

In the soils of Behar there is a great deficiency of organic matter. This might be rectified to a large extent by following the practice of the West Indian Islands in growing and digging in other crops between the cane rows, preferably crops of the leguminous order. There are many such crops, and the most suitable can easily be fixed upon after a little enquiry and trouble. These crops are planted between the cane rows, and are dug into the banks when bank tillage is in operation.

Pitting of Tops.—In December or January when cane cutting is going on, it may not always be convenient or possible to plant out the tops. These tops may be kept in pits for a couple of months if necessary. It is wise to sprinkle some disinfectant over the tops in the pits to guard against attacks of white ants or other pests.

Ratoons.—Where there is a good spring from the roots of the planted crop after cutting, it will be found economical to carry on the cane field for another year, that is, to reap a crop of first ratoons from the same field. When the spring is very irregular, it is useless to carry it on. To a very great extent a poor irregular spring from the plant cane is the direct result of bad cane cutting ; the cane has not been cut flush with the ground, or has been cut with a blunt implement. Another important point is to see that the crop is free from disease. If red rot is prevalent, a ratoon crop will not succeed. Again, some varieties of cane are more suited for ratoons than others. Assuming that it is decided to carry on the crop of first ratoons, the treatment should be as follows. If the trash is to be burned on the field, this should be done on the same day that the plant crop is cut, for otherwise the young shoots, which come to the surface immediately after the previous crop is cut, will be burnt and checked in growth. The cane rows should be forked over in order to loosen the crust about the stools, and some

earth drawn from the banks so as to cover lightly the cane rows. The ordinary 'kodali' is not a good implement for such work, as it cuts the young shoots, but a three-pronged "kodali" is suitable. This work should be done a few days after the cane is cut. In February or March, when tops are obtainable, all blanks in the cane row should be supplied and the rows made continuous. Where the supplies are planted, the rows should be dug with a pronged 'kodali' to a depth of 8 inches at least. The canes should be kept free from weeds until the time comes for the tilling of the banks. The banks should then be tilled in the manner described above, the rows being given a liberal dressing of earth at the same time. Artificial manures will be found to be the correct method of manuring ratoons, and doubtless the Agricultural Research Institute at Pusa will shortly furnish to the Behar sugar planters the formulæ of mixtures which will meet the case.

WEATHER CHARTS AND REPORTS, AND THEIR UTILITY TO THE INDIAN AGRICULTURIST.

By W. L. DALLAS.

Before describing the weather charts and reports issued by the Meteorological Department, or attempting to show how they can be utilised to aid us in forming a conjecture as to approaching weather, it is advisable to explain briefly the character and nature of the observations which are recorded at the Government Observatories. The principal observations registered at these stations are those of atmospheric or barometric pressure; temperature; humidity; wind; rain; weather; and sea disturbance. These observations are recorded at the same hour (8 A.M. local time), at all the different stations, and all the observations are corrected so as to be strictly comparable one with another.

Barometric pressure is measured by the barometer, and the readings recorded at the different stations are corrected (1) for the individual error of the instrument itself; (2) for temperature; and (3) for sea-level. Thus before the readings of the barometer appear in the report, they have been corrected according to the previously ascertained error of the particular barometer. They have likewise been reduced to a temperature of 32°F. The column of mercury in the barometer tube, like most other bodies, is lengthened by heat and shortened by cold, so that unless two or more barometers be precisely at the same temperature, they cannot possibly read alike; their readings have consequently to be corrected to a common temperature, which for convenience sake has been taken as 32°F. Further, as the barometer simply measures the weight of air lying over it, increase of elevation necessarily implies a diminished pressure, so that two perfectly similar barometers, one in the top floor and the other on the ground floor of a building, will record readings, the differences of which will be proportional to their difference of height. It follows that as the barometers placed at the various stations in India are at all sorts of different elevations, in order to compare their readings it is necessary to make a correction to bring them all to the same elevation; and for

convenience sake the level of the sea has been adopted as this common elevation.

Temperature.—The maximum temperature and the minimum temperature are registered by specially constructed thermometers which are read daily at 8 A.M. To obtain the *mean* temperature, the average of the maximum and minimum readings, as given in the Daily Weather Report, is taken and adopted as the mean temperature of the preceding day.

Humidity.—The amount of moisture contained in the air at any place is determined from the readings of a thermometer with its bulb encased in damp muslin as compared with the simultaneous reading of a dry thermometer, *i.e.*, a precisely similar thermometer the bulb of which is not so encased. It is unnecessary to enter into the theory of this difference, it being sufficient to say that the smaller the difference between the readings of these two thermometers, the greater is the relative amount of moisture in the air, and on this hygrometrical condition of the air our weather very largely depends.

Rain is measured by means of a raingauge, which shows the depth of water which would have accumulated on a level space of ground, had none of the rain escaped by drainage, evaporation and the like.

Wind.—The wind observations exhibit the direction whence the wind blows and its velocity in miles per hour as measured by an anemometer.

Weather.—The various observations which are comprehended under this general term are those which cannot be recorded instrumentally such for example, as thunder, hail, dew and the like.

Sea Disturbance.—The remarks under this head show for the coast stations the state of the sea, *i.e.*, smooth, rough, tremendous, etc. These observations are useful as indications of disturbed cyclonic weather at some distance from the coast.

The Indian Daily Weather Report in which the observations are published is issued from the head office at Simla. The first page consists of a summary of the observations recorded at meteorological stations at 8 A.M. on any particular day, and gives data for the preceding 24 hours. The second and third pages give in tabular form a mass of statistics of the actual observations recorded at each station. The following is a specimen, giving a few representative stations, showing the amount of tabular information contained in the report.

Station.	Pressure.		Wind.		Temperature.				Humidity.					Rainfall.			Weather Remarks
	8 hours corrected to 32°, sea level and constant gravity.	Change in past 24 hours.	Direction at 8 hours.	Miles per hour past 24 hours.	Maximum of past 24 hours.	Departure from Normal of Maximum.	Minimum of past 24 hours.	Departure from Normal of minimum.	Mean of day.	Change in past 24 hours.	At 8 hours.	Change in past 24 hours.	Cloud at 8 hours.	Past 24 hours.	Since 1st May 1906 to date.	Departure 1st May 1906 to date.	
Rangoon	29·777	−·042	S.	4	86·1	+0·2	76·4	0	81·3	+2·3	93	+ 2	6	0·89	23·97	+1·48	
Calcutta	29·516	−·036	E.	8	88·9	−0·9	77·9	−1·0	83·4	+3·7	88	− 2	10	0·39	6·97	−5·29	Showery.
Allahabad	29·388	−·110	E.N.E.	17	94·6	−4·7	79·5	—2.6	87·1	−4·5	75	+ 2	10	0·09	2·06	−0·67	Duststorm with rain.
Lahore ...	29·471	−·061	S.E.	4	105·4	−1·5	84·3	+4·2	94·9	+8·6	60	...	...	...	1·13	−0·65	
Karachi ...	29·444	−·065	W.N.W,	16	93·9	0	83·3	+0·6	88·6	...	80	− 2	10	...	0·05	...	
Bombay ...	29·510	−·134	S.S.E.	8	83·0	−3·5	76·5	−2·3	79·8	−0·5	89	− 2	10	0·19	7·25	−5·33	
Nagpur ...	29·343	−·089	W.S.W.	10	91·6	−3·0	74·1	−2·6	82·9	−9·2	98	+34	10	3·73	6·68	+0·99	Continuous rain.
Jubbulpore	29·330	−·091	N.N.E.	5	87·9	−4·9	76·3	−0·5	82·1	−9·8	91	+31	10	1·62	2·17	−2·86	
Hyderabad	29·538	−·078	W.	11	81·3	−10·6	70·7	−2·7	76·0	+2·2	84	− 9	10	0·05	6·82	+2·80	
Madras ...	29·615	−·040	S.S.W.	10	93·5	−4·7	80·5	+0·1	87·0	+2·2	61	− 1	6	...	2·34	−0·14	
Cochin ...	29·746	−·025	S.E.	8	82·2	−2·2	72·7	−1·7	77·5	−1·0	86	...	10	1·98	20·90	-11·92	

The report covers the whole surface of the Indian continent, observations being received daily from Baluchistan in the West to Burma in the East, and from Kashmir in the North to Ceylon in the South. The tabular matter shows the corrected barometric pressure and its change from the previous day; the wind direction at 8 A.M. and its mean hourly velocity for the preceding 24 hours; the temperature at 8 A.M.; the highest, mean, and lowest temperatures of the preceding 24 hours, and its change since the previous day; humidity at 8 A.M. and its change; cloud at 8 A.M.; the rainfall of the previous 24 hours and of the season; and finally some remarks as to weather and sea. The report of which the above is an abridged example is somewhat repellant in form, as it appears as a mass of figures, but all the more important data of the report are summarised in the charts which appear on the last page, and from which, when their proper significance has been fully appreciated, the principal features of the weather can be read at a glance. On the larger chart a series of black lines are shown which are known as isobars. An isobar or isobaric line is a line passing through those places where the barometric pressure (duly corrected as mentioned above) is equal, and in the case of the Indian Daily Weather Report they are almost invariably drawn for values of half-a-tenth of an inch. Thus we find on our illustrative chart isobars of the value of 29-40, 29-45, &c., &c. These isobars are drawn on all weather charts, and their distribution or course lies at the very foundation of all that we know about the weather. It will already have been seen from the tabular matter of the report that barometric pressure is far from being equal over the whole of the Indian region. It is greater in some places than in others, and if we proceed to plot the various values close to the different stations and to draw the isobars, we shall find that the values of these lines decrease from one region to another, and that several of these lines form closed curves around certain spots where the barometrical readings are either lower or higher than they are over the neighbouring districts. The districts of low pressure are known as 'depressions' or 'areas of low pressure' and the opposite conditions as 'areas of high pressure.' These areas, and the trend of the isobars generally, have an important influence on the wind's direction, and as it is on the wind's direction that most of our changes depend, they have consequently an important indirect influence on the weather. If any of my readers will imagine himself standing at any station or place on the chart *with his face turned* in the direction of the dominant area of low pressure, he will see that the wind he will experience shown on the charts by black arrows flying *with* the wind will be blowing from some point on his left-hand side, and the

PLATE XXII.

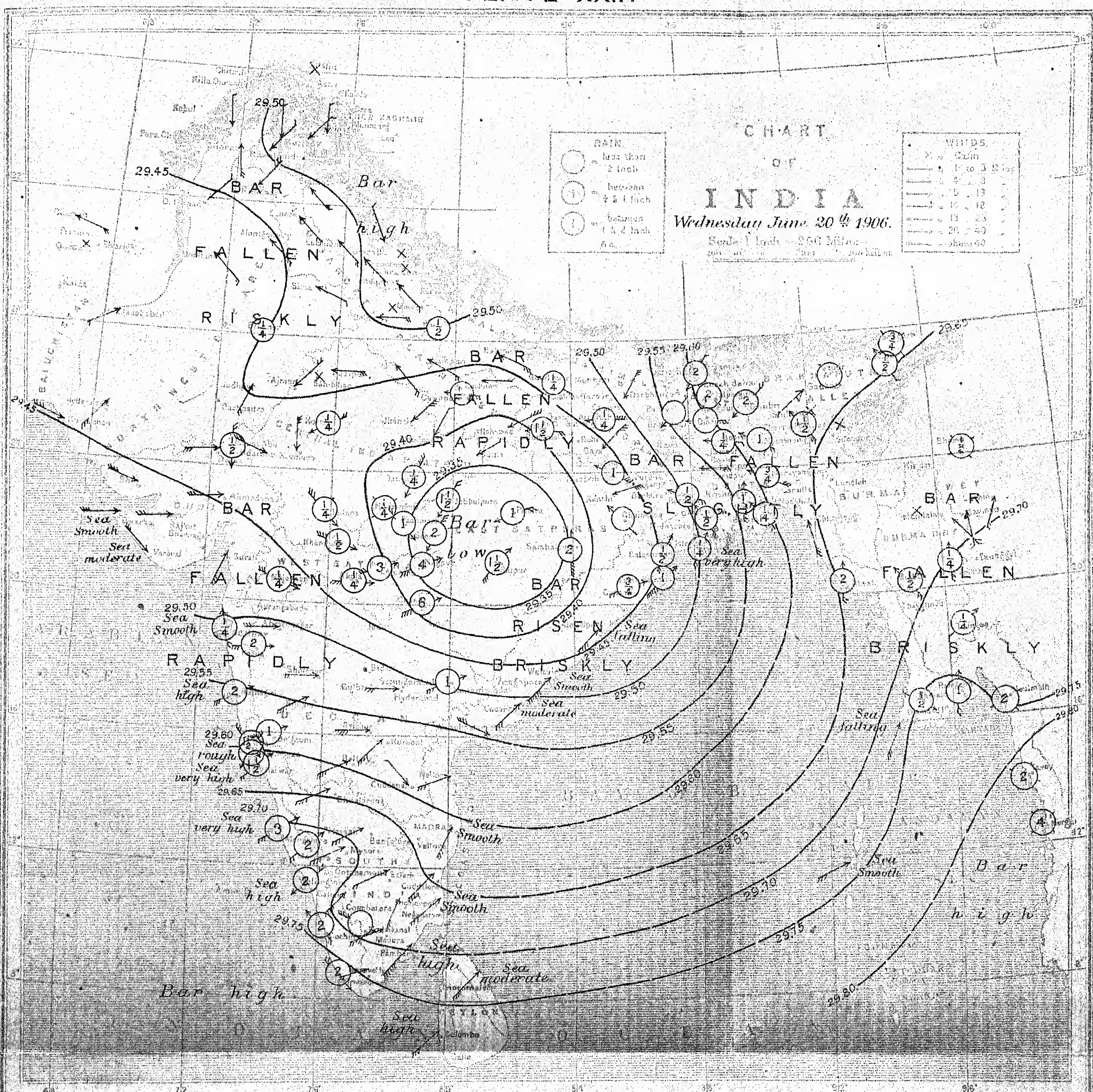
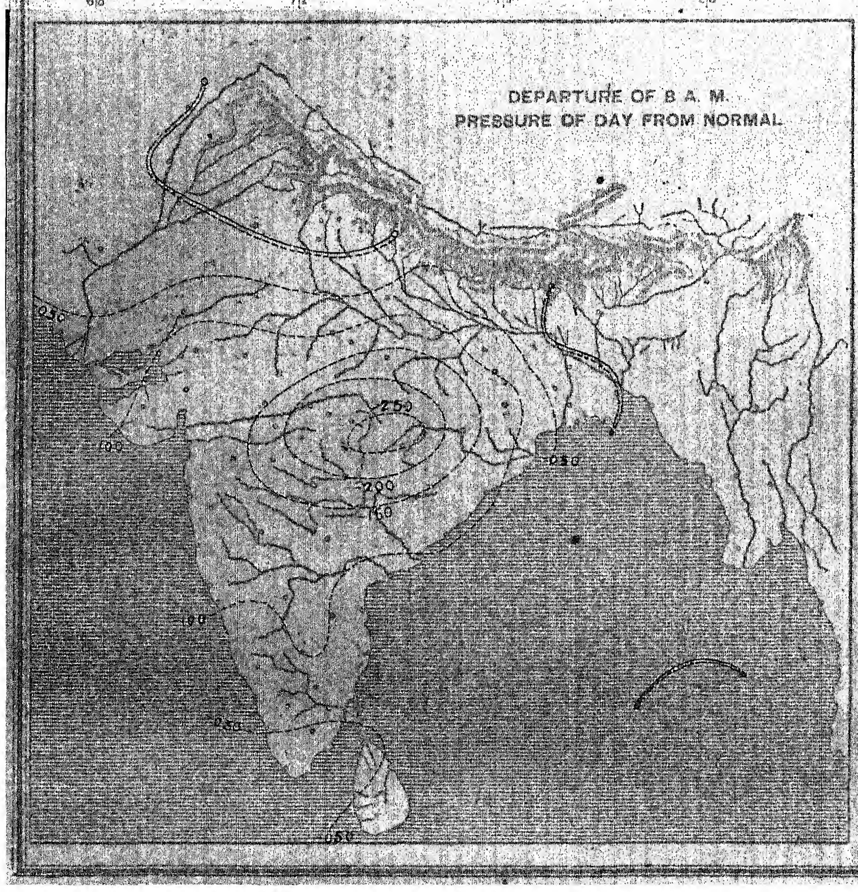
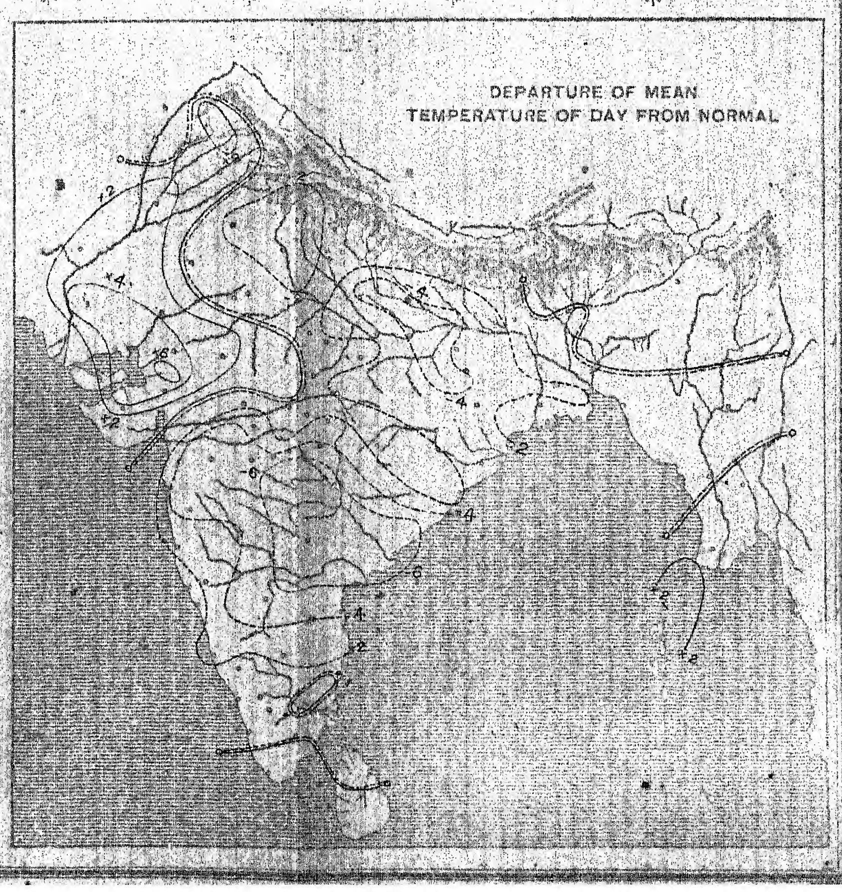


CHART
OF
INDIA
Wednesday June 20th 1906.
RAIN.
WINDS.
Calm
BAR FALLEN RISKLY
Bar high
BAR FALLEN RAPIDLY
Bar low
BAR RISEN BRISKLY
BAR FALLEN SLIGHTLY
BAR FALLEN BRISKLY
BAR FALLEN RAPIDLY
Bar high
Sea Smooth
Sea moderate
Sea high
Sea rough
Sea very high
Sea falling
29.45
29.50
29.40
29.35
29.55
29.60
29.65
29.70
29.75
29.80
BALUCHISTAN
MADRAS
SOUTH INDIA
CEYLON
Colombo


DEPARTURE OF 8 A. M.
PRESSURE OF DAY FROM NORMAL


DEPARTURE OF MEAN
TEMPERATURE OF DAY FROM NORMAL

closer the isobars lie together the stronger will be the accompanying wind, presuming always that the place of observation be properly exposed.

The consideration of the effect of the distribution of barometric pressure and accompanying winds leads naturally to the comparison of the two classes of atmospheric systems—'high' and 'low'—and the weather which accompanies them. High pressure systems are marked by (1) a very slow circulation of the air or light winds ; (2) a low temperature in winter and a high temperature in the hot weather ; (3) great dryness of the air ; and (4) absence of rain. These conditions are explained on the supposition that the air in the case of a 'high' system flows out from the centre and is supplied by a descending current, which cannot contain much moisture owing to the very low temperature of the very elevated regions whence it is drawn. Systems of high pressure hence bring with them light winds, hot or cold weather according to the season, low humidities and dry weather. 'Low' systems on the other hand are associated with the opposite of the above conditions. More or less strong winds according to the intensity of the system surround the 'low' area, and the surrounding winds flow in towards the centre where they ascend. Systems of low pressure or depressions consequently bring with them an ascending current, more or less cloud and more or less rain according as they draw into their circulations winds from a moist sea area. Another important distinction between high and low pressure areas is that the former are usually nearly stationary while the latter move.

Having thus described the fundamental data on which our knowledge of the weather depends, let us consider the particular chart which has been selected to illustrate this article and see how far the actual observations of a particular day fit in with the theorems stated above. Wednesday, the 20th June 1906, exhibited very satisfactorily the conditions which are typical of a slight storm during the rains. This storm had appeared off the North Madras coast on the 18th, had advanced slowly to the neighbourhood of Raipur on the 19th, and was central near Seoni on the 20th. The circulation of the wind (shown by the arrows) around the depression was well marked. The winds were westerly over the Peninsula, south-westerly over the Bay of Bengal, southerly to south-easterly and easterly over Bengal and the Gangetic Plain, and north-easterly to north-westerly over the Nowgong, Saugor, Jubbulpore, Indore and Khandwa districts. This circulation is characteristic of all storms and must be most carefully borne in mind, for on the direction from which the wind comes depends very largely the weather experienced, while direction of the wind at a given place depends on its position with regard to the dominant pressure system. Black circles with

figures enclosed show the area over which rain has fallen. Rainfall is an indication of an ascending current, and the amount of the ascensional movement is greatest near the centre of the storm and diminishes with distance from the centre; hence the chart shows that while there has been rain over the whole area controlled by the storm, the heaviest falls (Chanda 6 inches, Nagpur 4 inches, Amraoti 3 inches and Seoni 2 inches) are close to the centre, where the wind from the Arabian Sea was pouring into the storm and ascending. There are certain areas where no rain is falling and which hence require a word of explanation. The first dry area is the Deccan and the east of the Peninsula. The land over the Peninsula slopes fairly steadily from the west to the east, the elevation of Poona being 1,840 feet above mean sea-level, of Hyderabad 1,690 feet, and of Waltair (Vizagapatam) 226 feet. Thus the natural tendency of the air over this area must be to descend, following the contour of the land surface, and the storm was too far north for the ascensional movements due to it to overcome the effect of gravity. The second dry area is shown over North-west India. This area was obviously beyond the influence of the storm. The isobars were wide apart, the winds variable, and the whole region was beyond any ascensional influence of the storm, and the weather there was consequently hot and dry.

Below the main chart are two smaller ones. That to the left shows the departure of pressure at 8 A.M. on the day of the report from normal. The greatest pressure departure—·250″—is shown near the centre of the depression area, and from that point the amount of the departure decreases till over North-east India, along the foot of the Punjab Himalayas and over the south-east of the Bay of Bengal, there are areas where the pressure on the day in question slightly exceeded the normal. This chart practically reproduces in another form the barometric information given in the main chart, but it displays certain details which are useful for forecasting purposes. A storm ordinarily advances along the line of least pressure resistance. Thus the storm we are discussing would not ordinarily move to north-east or north where the barometer is high and the pressure contours steep, but would advance to the westward where the contours are slight and the resistance least. The chart on the right shows the departures of mean temperature from normal, and on the particular day in question shows the excess of temperature over the dry area in the north-west.

When considering what is the practical use to an agriculturist of weather charts, giving as they do a representation of conditions of weather already passed, it is necessary to acknowledge at once that the utmost they will permit a careful observer to do is to make an intelligent anticipation of coming events, an anticipation which may and indeed must frequently be incorrect,

but which on many occasions will not be without value. The charts can only be regarded as a useful aid to the local observer, but they will be found most useful to those who study them continuously and carefully and combine with them careful and systematic observations of their own meteorological instruments and their local weather. As the Daily Weather Report is published at Simla and does not leave that station until nearly 24 hours after the hour to which the observations refer, the Report can in many cases only arrive at its destination between 36 and 48 hours after date. In addition, however, to the Daily Weather Report, there is issued a telegraphic summary of the weather, which for any particular day will arrive at most places in Northern India at about the same time as the detailed printed report of the day preceding. The weather student has thus two sets of data which he can utilize in order to form a judgment as to the probable changes. The first thing to be done is to notice the general conditions of barometric pressure as shown on the chart and to determine whether the place of observation is under the control of a 'high' or 'low' pressure system. If the former, the probabilities are that the weather will be, and will continue fine, while if the latter, then the chances are that conditions will change from fine to cloudy and from cloudy to rainy. It hence follows that it is with the latter or cyclonic system that we are most concerned, and as a general rule it is as to the probable occurrence of rain that the agriculturist requires to be warned. In Northern India, speaking generally, 'cyclonic' or 'low' pressure systems travel from the eastward to the westward from April to October, and from the westward to the eastward from November to March, and rain usually accompanies these systems in their march across the country. It is therefore essentially necessary to watch the development and progress of these depressions, as it is in connection with these systems that nearly all the more important changes of our weather are ushered in. Thus in the majority of cases, the monsoon rains on both sides of India are brought up by a cyclonic storm ; the fine dry weather which prevails over Northern India during November and December is ordinarily broken up, and the winter rains are ushered in by a storm of this character ; while finally the storm rainfall of the spring months is in most cases associated with shallow small storms which are produced under the influence of the rapidly rising temperature.

As an example of the practical utility of the charts and reports, let it be supposed that an agriculturist in the Jubbulpore district in the middle of June of the present year was anxious to know when rain was probable in order to prepare for sowing his autumn crops. From 1st of May this year to the 17th June only ½ inch of rain had been received in that district, so that rain was urgently wanted and any indication of its approach would

prove useful. On the afternoon of the 17th he would read in the daily summary of the weather that 'a depression had been formed off the North Circars and Orissa coasts,' and he would naturally desire to know in what direction the rain-bearing storm would be likely to travel and whether it would pass over his district, give rain and enable him to break up his land for sowing.

It has been pointed out in an earlier paragraph that when an observer faces a low pressure area, the wind (provided the exposure be good) will come from some point on the left hand side. Conversely if the wind blows from a point on the left hand the observer will face the dominant low pressure area. Now, at 8 A.M. on the 17th June, the wind at Jubbulpore was blowing from west-north-west, so that an observer standing with his left side to the wind's direction would face a low pressure over the Sutna-Allahabad districts, and this was the case on the morning in question. At that time the wind at Jubbulpore was unconnected with the Bay disturbance. At 8 A.M. on the morning of the 18th, however, the wind at Jubbulpore had shifted to the northward, so that, though the weather was still fine there, the observer might safely say that his district had come under the influence of the storm which lay to the east of him. This view would be subsequently confirmed by the daily weather telegraphic summary which would have informed him that the storm off the North Madras coast had become deeper and more influential, and he would be justified in making all the preparations necessary to utilize as much as possible a heavy fall of rain. At 8 A.M. on the 19th, the wind at Jubbulpore was north-north-east and the sky was overcast, so that the storm obviously lay to the east-south-east of the district and was advancing towards that region. On the morning of the 20th, the wind was still north-north-east and 1·62″ of rain had fallen. The observer by standing with his left side to the wind faced to east-south-east, so that he would know that the storm centre had not yet passed over his district and that further rain and probably high winds were to be expected. Another fall of rain amounting to ·35″ was received during the 20th, but by the morning of the 21st the wind had shifted to south-south-east, so that the observer by turning his left side to the wind would face to west-south-west, and he would then know that the area of low pressure or storm had passed his district in its passage westward, and that the weather would probably clear up or at most be only showery. As a matter of fact the daily weather report of the 22nd showed that the weather had cleared and that the storm having passed no rain had fallen.

The above summary of the changes which took place at a particular spot during last June will, it is hoped, show that the charts and reports, both

telegraphic and by post, can be made into useful helps to the local observer, provided that he studies them regularly and combines with that study careful and systematic observations of the local weather and if possible his meteorological instruments. The charts themselves being from 24 to 48 hours old cannot be of much immediate service, but the weather prevailing over any district on a given day or during a given period is affected by, and may be described as the result of, conditions prevailing in the surrounding districts ; consequently by observing what those conditions have been in the immediate past, we are in many cases enabled to form some opinion as to whether the weather we are experiencing is likely to be comparatively permanent or transient in its character, and if transient in what direction the change is likely to take place. In some years the weather is almost permanently dry and the storms which arrive in due course give hardly any rain ; in others the weather is constantly wet and every disturbance which comes in gives a widespread downpour ; in some years the storms are numerous, following each other quickly at only a few days' interval ; in others they are of rare occurrence and long periods elapse without any indications of cyclonic action. These general characteristics of a year or season must be ascertained by carefully studying the daily maps, but having grasped these main facts about the weather, it is possible, by carefully watching the local wind and the changes of the barometer, combined with the more distant changes which are noticed in the telegraphic weather summary, for a local observer to make a fair estimate for some days in advance of the probable larger changes of weather which are likely to take place over a particular station or district.

THE CATERPILLAR PEST OF INDIGO IN BEHAR.

By H. M. LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist, Agricultural Research Institute, Pusa.

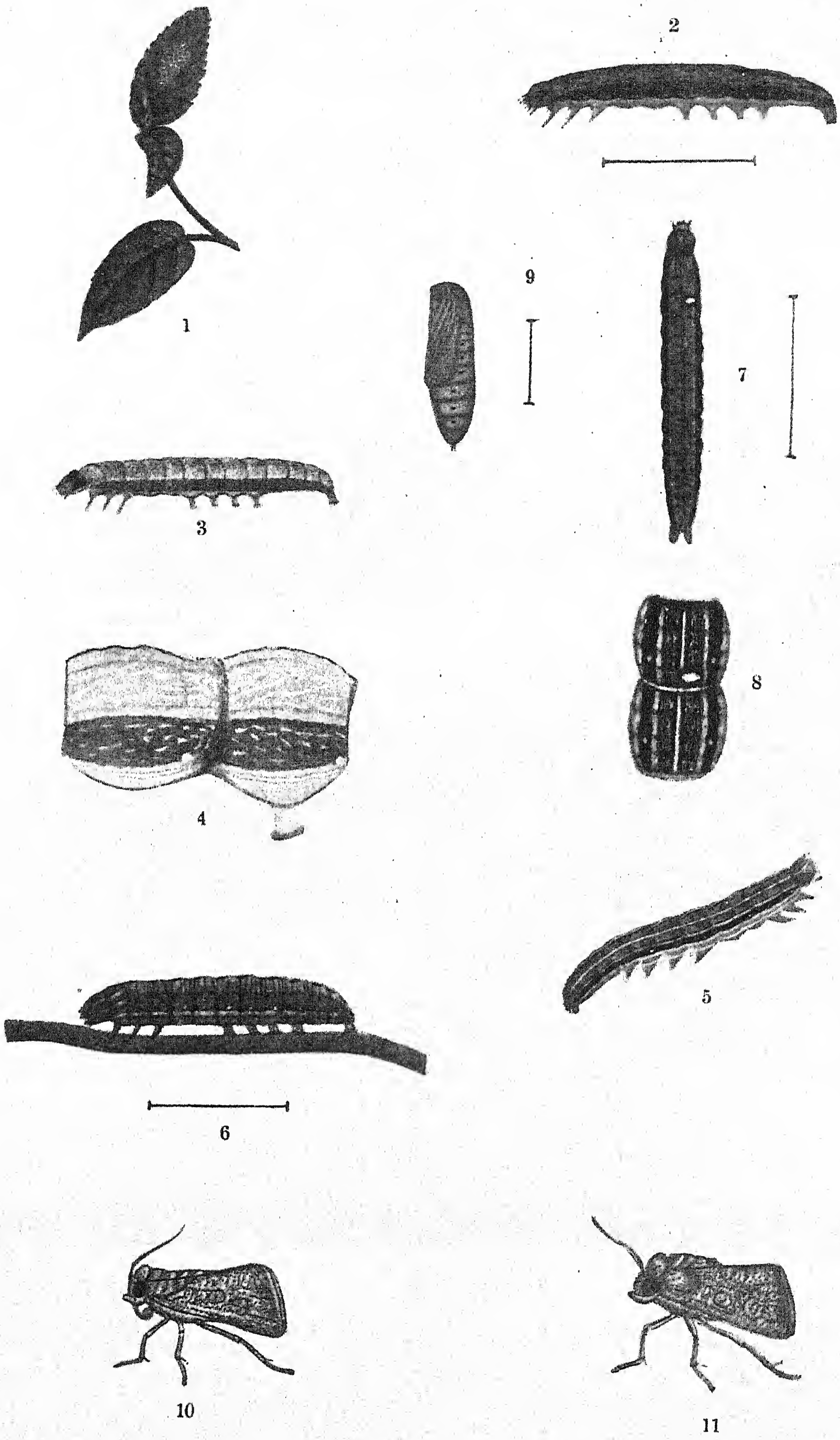
In some years the newly germinated indigo in Behar is swept off by a "caterpillar" pest, familiar to all indigo planters. This pest must not be confused with the caterpillar that later in the season swarms upon the cut plant and is found in abundance upon indigo steeping in the vats. These caterpillars are of distinct species. The former, which is the subject of this article, has not been reared from indigo during the rains, nor is it one of the many common caterpillars found upon indigo that is being cut. Its scientific name is *Caradrina exigua.* Apart from its significance to the indigo planter, this caterpillar is a sporadic pest principally of the irrigated vegetable crops of the hot weather; it is one of many of the leaf-eating caterpillars, which though common in the plains is not likely to be easily recognised. It is here discussed principally from the point of view of the indigo planter, and the suggested remedy, if generally adopted, would prevent any further losses from this pest.

Life History.

Eggs.—The eggs are of the typical noctuid form, spherical, with radiating lines; each is pearly white, similar to a poppy seed in shape and size. Before hatching, they deepen slightly in colour, the darker colour of the developing larva showing through the semi-transparent shell. Eggs are laid in clusters, the first eggs on the leaf, side by side, not touching and irregularly arranged; later eggs on the first. Between and over the eggs are short whitish hairs, which in quantity are buff coloured. If the egg cluster is small and consists only of 10 to 50 eggs on the leaf, it is usually not covered but only has hairs between each egg. (Pl. XXIII, fig. 1).

The number of eggs varies; there are abundant small clusters of some 10 to 40 eggs; whilst larger clusters have forty to over one hundred, and the largest some two hundred and more. Eggs are laid on the leaf, the

PLATE XXIII.



INDIGO CATERPILLAR.

situation depending upon the plant. On maize and large leafed *bhinda* (*Ramtorai*), the eggs are laid on the lower side of the leaf in large clusters. On young indigo the cluster is small, and is laid on the uppermost surface of a leaf. On lucerne, the eggs are laid on the uppermost surface of a leaf near the top of the shoot, the clusters varying much in size.

The eggs hatch naturally on the second day, *i.e.*, if laid on the night of the first, they will hatch during the day or night of the third. Being laid on the growing leaf, they are kept moist by the plant ; if laid in cages, or if the leaf is plucked and dried, the eggs still hatch normally. The temperature prevailing when all the eggs under observation have hatched has been high, the typical high temperatures of April in the plains, running up to and over 106° in the shade : even this temperature, with a very dry hot west wind, has not affected eggs on the plant or kept dry in the shade. The eggs, therefore, are not sensitive to a temperature of 106° in the shade with an air humidity of less than 30. The hot dry conditions prevailing with a west wind in Behar do not affect them, nor does the cooler moist east wind that also blows at this time.

Caterpillar.—The caterpillars on hatching leave the egg cluster and gather on the surface of the leaves. On young indigo, they web up the small leaves, joining them together with silk. If the indigo leaf is large enough, they simply web up a single leaf, joining the opposite edges with silk. On lucerne they either web together the leaflets or web up the whole top of the shoot. Within this shelter, the larvæ live gregariously, eating the epidermis of the leaf and gradually skeletonizing it. For two to three days they live thus in shelter, and then commence to separate. The larva is no longer gregarious, and moves about and feeds steadily on the leaf. With changed habits, it hides under shelter, on the surface of the soil, at the base of the plant, between the leaves when not feeding, and comes out to feed. As a rule they feed during the morning about 9 to 11 A.M. and then retire to shelter. From 4 P.M. again they are very active, moving from plant to plant in search of food. They are in this stage very voracious, steadily devouring the leaves ; a large amount of plant tissue is eaten and the leaves are rapidly stripped. They quickly increase to their maximum size and retain their active habits till full-grown.

The young larva is green, the head black. As growth proceeds, the colour alters, the white lateral band first appearing, the dorsal lateral surface then darkening as a regular band just above the lateral white line. (Pl. XXIII, Fig. 2). A little red pigment develops on the lateral line in indigo-feeding caterpillars, and the dark band above may not appear. (Pl. XXIII, Fig. 5). Superficially the indigo-feeding and lucerne-feeding cater-

pillars are much unlike, the broad dark band of the latter giving it a very distinct appearance. The figures do not express this very well, the figure (5) giving best the banded appearance of the lucerne-feeding caterpillar. Caterpillars, reared first on indigo and then on lucerne, become dark in most cases. The following is a description of a typical half-grown caterpillar on indigo :—a smooth noctuid form caterpillar, cylindrical, the head and prothorax small ; there are five pairs of prolegs ; the colouring is that of the Agrotinæ, uniform ground colour with stipples, a broad lateral band ; the dorsal area is green, with fine white and darker stipples ; the lateral band is, in full grown specimens, white with more or less red ; the ventral area is green ; the spiracles are oval, set on the lateral line, black rimmed, white inside and with a white area round. The colouring varies, the red on the lateral line being absent from young specimens. There are short dark hairs on each segment, and particularly on the head and tail. The full grown caterpillar is of very diverse colouring and no adequate description can be drawn up. Figures 2-7 in Plate XXIII represent typical caterpillars. Apart from the colouring, the caterpillar is the typical smooth larva of the Agrotinæ, with short hairs, with five pairs of sucker-feet, and without humps or protuberances.

When wholly full-grown and full-fed, the caterpillar seeks shelter, usually on the surface of the soil at the base of the plant, or under a stone, or among leaves or other material on the ground. Where necessary a small amount of webbing is produced as a covering and a very rough cocoon is formed with bits of leaf or other material.

Pupa.—After the usual rest, the pupa is formed. The chrysalis is of the usual noctuid form, with a double spine at the tip of the abdomen. (Fig. 9, Pl. XXIII). The interesting point about this stage is the duration, which varies very largely according to (1) temperature, and (2) atmospheric humidity. When the temperature goes down in November, the full grown caterpillars turn to pupæ, after hiding away in a sheltered place. Any that have already turned to pupæ remain as pupæ so long as the temperature is low. This is the ordinary 'hibernation,' the method adopted by the insect of protecting itself against cold. As the air warms in February, the conditions become favourable for moths to hatch, but the air is now drier and, if a west wind blows, may be very dry. Then, though the temperature may be high, moths will not hatch until the air is moist, and this is the normal method the pupa has of behaving ; with the first moist warm wind they in dry conditions hatch out. Actually, hot dry air either prevents the moth hatching or delays it ; pupæ kept in quite dry air often fail to hatch at all or are delayed, but with the first moist air they hatch out quickly. The period of pupation may then be very long (three months) in winter, very short (five

days) in normal moist warm weather, or any period between the two when the air is hot and dry. The importance of this influence of cold or drought upon the length of the pupal stage is discussed in a later paragraph of this article.

Moth.—The imago is a small moth, whose appearance is best realised from Figures 10 and 11, Plate XXIII. It hides in shelter by day, coming out at dusk to fly in the fields. I have never caught it at light and believe it to be a light-shunning species.

The length of the life-history varies, the most rapid being as follows :—

Egg, two	days	eighteen days or less than three weeks.
Larva, nine	,,	
Pupa, five	,,	
Moth, two	,,	

This was in the insectary with abundant food. In the field, it appears to be somewhat longer, the larva living even as long as a fortnight with plentiful food. The period between the time the egg is laid until the moth again lays eggs is from 17 to 30 days normally. Whether the broods will succeed each other so rapidly throughout the year depends upon circumstances. In the absence of food the moth lives for some time until she can lay eggs. It is probable that from November to March the insect normally hibernates as a pupa, except in exceptionally moist warm areas of India (*e.g.* parts of Lower Bengal).

Damage.

This insect occurred in great numbers in Surat in April and May, 1904, the larvæ being found in a plot of land, irrigated from a well, on which maize, bhinda (*Hibiscus esculentus*) and bhimada (*Amaranthus sp.*) were grown together. The caterpillars eat all these crops freely.

In the following year, immense numbers were found destroying the lucerne crop of the Pusa experimental farm ; the first sign of the pest was the great numbers of caterpillars found eating the crop ; active measures had to be taken at once, as it was already too late to check all destruction. Twenty seers of caterpillars were actually destroyed, a seer containing 12,000 caterpillars. It was estimated that this was rather more than half the actual number which may be put at 400,000. Allowing each moth a production on the average of 200 eggs, this requires only 2,000 female moths, or 4,000 moths in all as parents ; the previous generation (in March) would, therefore, require only sixteen female moths as parents, or 32 in all, to survive the winter. Assuming then that 32 moths emerged from hibernation, found

mates and laid eggs in March, the April outbreak is accounted for. I do not suggest that only this number actually survived the winter, but this is the minimum necessary.

After this, the third brood of caterpillars was not definitely found. An enormous percentage of caterpillars were parasitised in the large second brood, but what this percentage was could not be definitely ascertained; of the caterpillars counted over half had *Tachinid* eggs outside. In addition many were destroyed by Ichneumons whose eggs are laid inside; and digger wasps (*Ammophila*) were busy carrying off the caterpillars. *Carabid* beetles ate others as did the predaceous bug *Canthecona furcellata;* finally mynas feasted on the hordes of caterpillars. The field was a scene of insect carnage. How many survived cannot be even estimated. After this attack stray broods were found during the rains on various plants including Amaranthus and various weeds, besides lucerne.

None of these broods were large and definite, but the insect was scattered, a normal member of the fauna, behaving as do other such moths with irregular broods until November and then hibernating during the cold weather; unless the insect had been very abundant it would not probably be found on crops, as wild foodplants (leguminous weeds) occur abundantly in the rains.

In 1906, precisely the same phenomenon occurred at the Pusa Farm; in this case the first brood was found and partially destroyed, so that the second brood was largely checked. The eggs of the early brood of caterpillars were first found on the 15th March; the large second brood of eggs was destroyed on April 18th and 19th. The sequence was apparently much the same; the early moths emerged, laid eggs and produced the first brood (March 15th). They transformed, laid eggs and the immense second brood was found. On April 18th and 19th a large quantity of eggs was collected on the lucerne. They were estimated by weight and count at 2,414 clusters. Two days later, a small fresh batch was laid, and it was found that in spite of the great number removed, the field was infested with eggs and caterpillars to a considerable extent. The field was accordingly cut right over and the caterpillars starved. Starvation produced but little effect, the larger ones pupating, the smaller ones waiting for a week until water was applied and the plant started growing again. There were small irregular broods during May and June, but the parasites gradually increased and the percentage of parasitised caterpillars eventually became a very high one, rising to 50 and in some batches to nearly 90 per cent.

In three successive years we have the same phenomenon observed—the occurrence of the pest in April in large numbers—and there is other evidence

that it occurs frequently. The curious behaviour of the insect merits a word of explanation. We must remember that in each attack the maize and the lucerne has been the only available crop, and that only in a small area. The lucerne in Pusa is about three acres, is irrigated and offers a fine growth of moist green plant at a time when no other crop of the kind is available. Accordingly all the moths gather there, and give a quick and healthy first brood which gives us an enormous second brood. In the rains, this brood would be scattered over the country side and not be noticed. The phenomenon is, therefore, perfectly natural, illustrating how our artificial methods of growing crops upset natural conditions.

The occurrence of this pest on lucerne is not the important fact but leads up to the occurrence of the pest on indigo. It is now known that the "caterpillar" which attacks young indigo is this insect. I have had but one season to study this pest on indigo, but my previous experience of it has enabled the life history to be carefully worked out, and little observation was required to note the peculiar points of its attack on indigo. Indigo is sown in March and April and comes up quickly. At the same time the moths emerge from hibernation and lay eggs on the young indigo. They lay small clusters, fairly well scattered. The caterpillars hatch, web up the leaves and give rise to the cobweb appearance noticed by planters. In a day or two they move out and feed more widely. A single egg cluster means much damage in one spot; a half-grown caterpillar requires some twenty "two-leaf" indigo plants a day; it will entirely destroy a larger plant daily. A single cluster of 40 eggs causes havoc in the area round about, say for perhaps ten yards radius; ten such clusters may result in the destruction of a large area. This is actually what occurred at Hursingpur in 1906. Caterpillar was not plentiful as it was on the lucerne at Pusa (*i.e.*, some 100,000 per acre) but was well scattered; yet this was sufficient to destroy a large acreage of young indigo. A moving half-grown caterpillar bites the epidermis of the upper surface of each of the two first leaves and then moves on. That plant, under certain circumstances, dies. The destruction is thus very widespread, if there is a fair number of such moving caterpillars in a field. Supposing the caterpillars destroy the field, what can they do? They do what they did in 1906 when the lucerne was cut, wander out of the field seeking for food. If they then enter a field not attacked they will play havoc with it. This is, I believe, what occurs in a normal caterpillar year in indigo districts.

There are some other points, which must be specially noticed. Why are some fields attacked and not others? The better form of the question is why do the moths lay eggs in some fields? It is difficult to say

what guides a moth in her choice between two fields; perhaps she comes to one first, perhaps the plant is finer or better growing. No one can answer this question, but if we realise that the choice rests with the moth and that it is not a question probably of a "seeted" or "unseeted" field, we can see that the point is immaterial. What has the east or west wind to do with it? To planters the east or west wind is always an important factor. The east wind is a moist moderately warm wind blowing up from Bengal; the West wind is a dry parching wind, where the temperature rises up to and over 106° in the shade and the percentage humidity in the air is from 10 to 30. In the east wind, moths hatch out; the two big egg-laying nights on lucerne at Pusa coincided with an east wind; in the insectary, a moist atmosphere or a moist east wind brings the moths out; in a dry atmosphere, at the same temperature, the moths either fail to hatch or hatch late. The prevalence of east wind is favourable to moths hatching, the west wind unfavourable. Therefore, if there are on the 1st April numbers of caterpillars pupating, and an east wind blows on the 3rd to 7th, the moths come out and lay eggs about the 6th; caterpillars then appear on the 10th. If the west wind blows till the 10th, and then an east wind, moths hatch out on the 11th and the eggs are laid; the planter sees cobweb on the 14th and says the east wind brought caterpillar. There is another effect of west wind which I would commend to the notice of planters. In a dry west wind, a plant bitten by caterpillar withers far more quickly than in an east wind; a planter has caterpillar, but his field looks green and he does not see it because the moist east wind preserves his plant. Next day a west wind blows, with the result that on the following day all the plant nibbled by caterpillar is dead. That planter may say the west wind killed his plant and not caterpillar or he may think back to the east wind, which he says brought it. I have had a variety of opinions expressed to me, but all can be reconciled with these two facts—(1) an east wind assists moths to hatch and to lay eggs; (2) a west wind kills plants bitten by caterpillar.

It may be remembered that a west wind does not injure *caterpillar* provided there is green food obtainable. Similarly a west wind does not affect the eggs. Caterpillar can be readily reared in the driest hottest wind if it has moist food. When, however, a young field is struggling against caterpillar in an east wind, and a west wind blows and dries up the plant, the caterpillar will die also. A re-sowing then may be successful. A curious fact told to me by planters of experience is that if a plant recovers, it is not again attacked; but if a field dies and is re-sown, it is likely to be re-attacked. My knowledge of the intimacies of the life of the caterpillar and what is more important, the moth, is not deep enough to solve this problem without

a certain amount of theory, but there is probably some difference in the composition of the leaves of the later plants. For the indigo planter, the salient facts are that if the emergence of the moth in any quantity coincides with the germination of his indigo, he is likely to get the eggs laid on the plant and so get a "caterpillar year." If an east wind brings out the moths at the right moment, the crop will suffer. Should the west wind be blowing and the moth delay till the indigo is well up, or should there be few or no moths, then the young crop is likely to escape. If it were possible to sow indigo earlier and get the plant established before the moth could hatch, the crop would probably withstand caterpillar and suffer less. This point is curiously illustrated by the following quotation from a letter from Mr. Murray. "It may help your investigation to know that 30 years or so ago, this concern used to have a caterpillar plague almost every year. We noticed, however, that the 'jatchings,' that is, the sowings where the drills were tested, (the testing generally beginning about the middle of February,) were hardly ever affected by the caterpillar. We then decided to sow earlier in the concern, to begin sowing about the 23rd to 25th February instead of 7th March, and we found that these early sowings almost invariably escaped or only had the plague to a small degree. We did not find this early sowing to be an actual specific; but most undoubtedly the early sown plant was to a very great extent immune. Of course the caterpillars do harm, even if the plant recovers from their attack. Its growth is checked for at least three weeks, and no one can assert that this is a benefit."

I believe planters generally will corroborate the statement that caterpillar is really destructive in quite young indigo only, and that it does far less harm when once the indigo is well established. At the present time of sowing, the young plant is at the critical time when moth emerges and lays eggs, and it is just the coincidence that brings about the severity of the attacks.

Remedies.

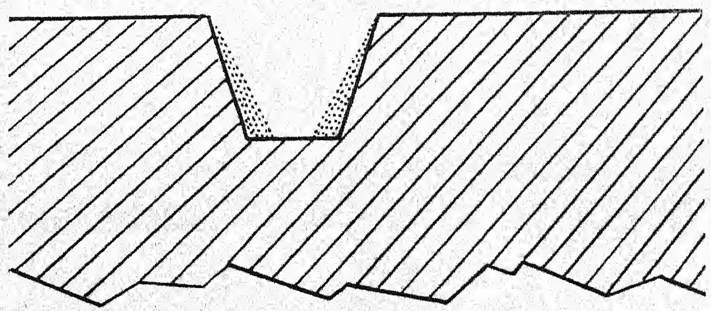
So far as our present knowledge goes, this pest is important (1) as the caterpillar that attacks young indigo; (2) as an occasional pest of irrigated crops in April and May.

Indigo planters regard "caterpillar" on their young crop with very varying degrees of importance. Many appear to regard it as a serious pest, others believe it is less destructive than the west wind. I attribute the destruction of young indigo to "caterpillar" and so long as the Sumatrana indigo plant (as opposed to Java-Natal) is sown as at present, the

caterpillar will be a more or less serious pest, occurring irregularly. The fact that it only comes at irregular intervals must be remembered, and there is no means of knowing that it will come till it actually is found on the plant. There are three lines of treatment :—

(*a*). To sow Java-Natal indigo in place of Sumatrana. Planters who substitute Java-Natal will not suffer from caterpillar, both from the different time of sowing and the apparent immunity of this plant to the insect. Java sown at the same time as Sumatrana was not attacked in 1906. How far this preventive is available is not a matter that can be discussed here, but it is a point in favour of the substitution of Java-Natal for Sumatrana indigo.

(*b*). A significant fact is that in 1905, though there was a considerable acreage of Sumatrana indigo in the Pusa farm, no caterpillar was found upon it, but only on the lucerne. In 1906 though caterpillar was abundant at many estates, it was in Pusa abundant again in lucerne and was not destructive on fields of indigo at Dhuli close by, and only slightly so at Birowli. In both years the lucerne was attacked in preference to indigo. It would then appear that we have a fairly simple preventive, namely to grow a small area of lucerne under irrigation, as a trap crop for the pest. How far this is possible I cannot say, but it would seem to be a method worth the careful attention of indigo planters. In the Pusa experimental farm, three acres of lucerne have been sown each year in October, which are periodically irrigated and cut to supply fodder for the cattle. The crop is a very valuable one for this purpose. On an indigo estate, an acre of lucerne at each outwork and at the factory would probably be sufficient. I would surround the plot of lucerne with a trench six to eight inches deep, with sloping sides of loose soil as in the accompanying diagram. On the



experience of two seasons at Pusa, there will be first a small, then a large brood of caterpillar on the lucerne. The indigo will not be attacked at all. The lucerne can be cut in rotation as is done at Pusa, and the fodder

will be valuable. I would not destroy the caterpillars. Picking off the egg clusters is advisable, which can be readily done by a very few boys; all will not be found, but the second brood of caterpillars will probably be destroyed by parasites and other enemies, whose increase will be beneficial to the checking of other pests on the later crops. That is, I would pick off egg clusters if possible; I would let the rest of the caterpillars eat the lucerne, isolating them in it by means of the trench, and using them to breed the abundant parasite, &c., which will be of such value later on in the season. Any other measures to destroy the caterpillar on lucerne must either unfit the crop for use as fodder or entail more expense than the crop is worth. At the same time the data given below as to the means adopted for checking the pest on lucerne will enable any planter to decide for himself if he will destroy caterpillar.

The value of the lucerne is primarily to draw the caterpillar off the indigo, secondarily to provide fodder. It is not necessary that the lucerne should be sown in October and irrigated till March. If at least four-fifths of the field always has a good growth of lucerne from March 10th to April 20th, the desired object will be effected. Sowing lucerne in October with no subsequent irrigation will produce a crop, which cannot, however, be periodically cut. Where irrigation is available, say in March and April, its cost will be more than met by the fodder which can be cut in rotation, always leaving four-fifths of the field in green lucerne to act as a trap to moth.

(*c*) It is unlikely that the sowing of lucerne as a trap crop will be adopted generally, and it is probable that there will be outbreaks of caterpillar on young indigo on estates that have taken no precautions. It seems worth while to discuss what can be done in such cases. Rolling the plants or running a hanger over the field is useless; the caterpillar will escape in the crevices not reached by the roller or hanger. Spraying the young plants is feasible and should be a most simple operation. A cart on which is placed a barrel and pump attached to a long iron tube arranged across the back of the cart just above the ground, with nozzles fixed at intervals on the tube will, acting like the ordinary road watering cart, spray a very large area. The width of the iron tube with nozzles should be as wide as possible. The cart simply goes up and down the field as rapidly as possible, a coolie in the cart working the pump. The initial expense of such an outfit would not exceed Rs. 100 at the most, and the cost of spraying material would be under Re. 1 per acre. The cost of labour cannot be estimated till the daily acreage done is known. Such a machine used in Australia in spraying wheat covers 15 acres an hour and has a width of 50 ft.; the sections of piping that project on each side of the cart are removable and are put on only

when the cart is in the field. With such an arrangement 100 acres daily should be covered, more if the matter is urgent; and by taking the worst fields in order, any ordinary outbreak should be checked. I do not advocate such an arrangement, but describe it because it is feasible and may appeal to indigo planters. If such spraying was the only remedy I would advocate it.*

The pest must also be considered as an occasional pest to other crops. In 1905, when the lucerne was being destroyed by it, coolies were employed to run large bags over the fields, sweeping up the caterpillar. Illustrations of these bags are given in "Indian Insect Pests" (pages 72-73). The bags were used between 9 and 11 A.M. and between 4 and 6 P.M. In four days' work, twenty seers, estimated to contain 250,000 caterpillars, were destroyed, and the bulk of the damage averted. Bags cost about Rs. 3 each, and for five acres of lucerne, six coolies were employed for four days. In 1906 the attack was expected; eggs were accordingly collected, the two days' work yielding an estimated number of 2,414 clusters. The number of eggs per cluster averages about 100. The work was finished in two days. It was then found that, more eggs having been laid two days later and some number of caterpillars having hatched from eggs missed or already hatched before egg collecting was commenced, the best plan was to cut over the field and starve the caterpillars. This was accordingly done and no further trouble experienced, a fresh growth of lucerne coming on. In small areas of irrigated crops as at Surat, no remedy can be put into the hands of the cultivator at present. It is feasible for him to remove the eggs and caterpillars, but he does not know the eggs and prefers not to destroy the caterpillars. In Surat, the field was very thickly sown with a mixture of crops and there were many weeds. The cultivator then removed the weeds and much of the crops, leaving the best plants which had escaped. His loss was thus small, enough plants being left to give him a full crop.

Identification.

At present, it is impossible to be certain of the identity of the insect except from the winged (imago) stage. The fact that the eggs are white, ribbed, laid in clusters with a covering of hair, does not do more than point to the eggs as those of a noctuid moth. The larva is of the typical form found in the Trifine divisions of the noctuidæ. Its colouring distinguishes it from some caterpillars, and it is clearly distinct from most common

* Details of the machine will be supplied on application.

caterpillars; but it alone cannot be specifically identified. The pupa is similar to many others. The combination of all these facts, together with the habits of the pupa, is not sufficient even to distinguish the insect as a *Caradrina*. A caterpillar similar to those figured here, hatching from similar eggs, on one of the food-plants named, may very likely be *Caradrina exigua*, if found in March, April, May, under circumstances as described above. The indigo planter is probably safe in identifying his "caterpillar" with this insect (not the caterpillar of indigo in the rains). Final and conclusive identification can be obtained only from the moth and then only with extreme care. Those who have some technical knowledge of moths may see the characters of the genus defined by Hampson "Moths, Fauna of India, Vol. II." For others, the figures on plate XXIII are the only useful means of identification, short of the simplest which is to send the caterpillar, chrysalis or moth for identification, the first two being sent alive.

Distribution.

The pest has been reared in Pusa, Surat and Kaira, from lucerne indigo, *Amaranthus Spp.*, *Celsia coromandeliana*, Senji (*Melilotus parviflora*), maize, bhindi (*Hibiscus esculentus*), and some weeds. The Central Provinces entomological assistant (Ratiram Khamparia) reared it from cotton, maize and safflower. Mr. Hayman reared it on gram (*Cicer arietinum*) in the Cawnpore farm. It is recorded in Indian Museum Notes, Vol. II, p. 10, as reared from linseed from Patna. (See under *Laphygma*). It has been sent from Narainganj and Bogra, Eastern Bengal, as a pest of jute, and it attacked jute slightly in 1906 at Pusa.

Hampson gives its distribution generally as Europe, South Africa, North and South America, Honolulu and throughout the Oriental region, while the Indian Museum has specimens from Karachi, Dehra Dun and (Dudgeon collection) Sikkim.

In Indian Museum Notes will be found the late Mr. de Niceville's notes on "Indigo Caterpillar," under the heading *Agrotis segetis*, Sch. (Vol. V, p. 145). Though Mr. de Niceville knew that a *Caradrina* has been reared from the indigo caterpillar formerly sent in, he reared *Euxoa* (Agrotis) *segetis* from a caterpillar sent in to him and so put all his notes under that heading. The information there given by indigo planters does actually refer to *Caradrina exigua*.

Enemies.

Like other pests, *Caradrina exigua* has enemies, which normally keep it in check. These include (1) Parasites; (2) predators; (3) birds.

Among the parasites, the most important appears to be a fly, similar in general appearance to the house flies, but belonging to a distinct family (Tachinidæ). This fly may be seen in the lucerne fields; if observed it will be seen to be flying and settling near caterpillars; suddenly it flies up, alights on the caterpillar and deposits an egg on it. The egg is semifluid but hardens at once to a hard white object, a small white spot (see Pl. XXIII, Fig. 8). This egg is usually laid on the upper part of the body, on the second segment behind the head. Possibly this position is chosen as it is not possible for the caterpillar to bite off the egg, but occasionally the egg is laid on the last segment. The caterpillar appears to have a vague knowledge of its foe and is very irritable, twisting quickly when the fly settles. The fly has to be very agile to lay its egg. Caterpillars with these white spots are doomed; they feed and grow, but within them the maggot hatched from the egg is feeding and, when presently they turn to chrysalides, from each chrysalis there comes, not the moth, but the fly.

Other parasites in the form of ichneumons have been reared; these are wasp-like flies, not so common as the Tachinid fly but which equally destroy the caterpillars.

Predators are insects which feed upon caterpillars. Among the more important is a wasp (*Ammophila* Sp.) which stings the caterpillars, thereby paralysing it; it then flies off with it, lays it in a burrow, and deposits on it an egg. The egg hatches, the grub feeds on the paralysed caterpillar and becomes in due course a wasp. There are also small beetles (*Carabidæ*) which feed upon the small caterpillars. A bug (*Canthecona furcellata*) is also found, which sucks out the caterpillars and thus kills them.

Mynas are fond of caterpillars and gather in the lucerne fields for a meal. They should not be frightened off as they do much good.

EXPLANATION OF PLATE.

Fig. 1. Egg cluster on indigo.
,, 2. Caterpillar, a week old, fed on lucerne.
,, 3. ,, fed on indigo. x $1\frac{1}{2}$.
,, 4. ,, two segments to show colour. Magnified.
,, 5. ,, full-grown, fed on indigo.
,, 6. ,, full-grown, fed on lucerne.
,, 7. ,, full-grown, fed on lucerne, with egg of Tachinid fly.
,, 8. ,, thoracic segments, to show egg of Tachinid fly.
,, 9. Pupa.
,, 10. Moth, male.
,, 11. Moth, female.

THE IMPROVEMENT OF THE COTTONS OF THE BOMBAY PRESIDENCY.

By F. FLETCHER, M.A., B.SC.,

Deputy Director of Agriculture, Bombay Presidency.

I.—INTRODUCTION.

A WORD of preliminary explanation seems necessary with regard to the term 'improvement' in relation to cotton. The quality of cotton-fibre in contradistinction to the plant depends on the following six factors in the fibres which compose it,—

(*a*) length,
(*b*) strength,
(*c*) fineness,
(*d*) uniformity, } constituting the "staple";
(*e*) colour,
(*f*) cleanness } determining the "grade."

Other less clearly defined qualities are "bulkiness" and elasticity. The matter is, however, not so simple as it might first appear, for the value of a sample of cotton does not vary directly with all the factors above mentioned though it does with most of them. Thus if one of the factors of length, strength, uniformity and cleanness increases, while the other five factors remain the same, it may be said with certainty that the value of the sample increases also ; if, however, the fineness increases while the other five factors remain constant, the sample does not necessarily increase in value. This is due to the fact that different styles of cotton are used for different purposes. Thus while Sea Island and Egyptian are used for the manufactures of an extremely fine and strong material (muslins, laces, mercerized cotton goods, sail cloths and the like), and American, Broach and other medium cottons for the manufacture of ordinary calicoes, the roughest types of cotton, such as Bengals and Khandesh, though used to a certain extent for mixing with finer growths, are also largely used for mixing with wool in the manufacture of

worsted goods. Now for the manufacture of calicoes the finer and smoother a cotton is the better, while for mixing with wool roughness is required. If then we increase the fineness of such growths as Bengals and Khandesh which, as far as the purposes to which they are put go, may be considered to be on the borderland between cotton and wool, we increase their value as cotton but decrease it as wool. The question then arises whether an improvement in these growths should be attempted in the direction of fineness or of roughness. In the case of the superior growths such as Egyptian, American and Broach, there can be no doubt that improvement should be attempted in the direction of a longer, stronger and finer fibre. As an example of a coarser and shorter cotton that is more valuable than a finer and longer one to which it is in other properties similar, the Comilla variety may be mentioned. This cotton may fetch a price as much as 25 per cent. above ordinary Bengals and Khandesh owing partly to its being picked cleaner but partly also to its being rougher than the latter. As 'Kapas' (seed cotton) its price compared with those mentioned is still greater, owing to the higher percentage of lint to seed contained in it.

2. The six qualities that determine the value of cotton to the manufacturer are stated above. From the cultivator's point of view, the value of a variety of cotton—the plant in contradistinction to the fibre, depends on :—

(*g*) yield per acre of seed cotton,
(*h*) price of seed cotton,
(*i*) hardiness of the plant, and
(*j*) method of ripening.

The yield per acre is of the very greatest importance, but for the purpose of deciding the question of the superiority of one or other of two competing varieties, is indissolubly bound up with the question of the price of the produce. The point can be settled only by actual experiment in the field. As an example we may quote the fine-stapled 'Bani' of Hinganghat which has been largely replaced by the coarser 'Jari' or 'Varadi,' and here it would appear that the producer and consumer (or rather a particular class of consumer) may be anxious to proceed in opposite directions. Thus the Lancashire spinner would prefer that the finer Bani should be grown since he cannot use the coarser Jari, while the cultivator may urge that Jari gives him a larger yield per acre and that the price obtained from the worsted-manufacturers of Saxony, though not so high per maund as that obtained for Bani, is such as to make the value per acre of Jari greater than that of Bani.

3. The price of seed cotton again depends on (*a*) the value of the cotton, and (*b*) the percentage of cotton to seed. It is obvious that the ratio to one

another of the prices which the cultivator receives for equal weights of seed cotton of two different growths is not necessarily identical with the ratio between the prices of equal weights of the cotton of the two growths. Seed cotton of one variety may be even dearer than seed cotton of another variety, while the cotton itself of the latter is the higher priced of the two. Thus if seed cotton of Bani is worth Rs. 7 and of Varadi Rs. $7\frac{1}{2}$ per Bengal maund, the cotton in Bombay may be worth respectively Rs. 235 and 200 per candy. These figures are easily reconciled. The percentage of cotton in seed cotton is in the case of Bani 25 and in the case of Varadi $33\frac{1}{3}$. From four maunds of seed cotton of the Bani variety, therefore, one maund of cotton is obtained, while the same quantity of cotton is obtained from three maunds of Varadi. Now if we take Re. 1 per maund of cotton as ginning charges and another Re. 1 as the rail charges to Bombay, and if we take the value of the seed to be Rs. 2 per maund, we have (neglecting profit and broker's commission) :—

		Rs.			Rs.
Bani ...	Seed cotton (4 maunds)	28	produces ...		
	+ Ginning ...	1		Cotton (1 maund) ...	24
	+ Freight on cotton ...	1		+ Seed (3 maunds) ..	6
		30			30
		Rs.			Rs.
Varadi ...	Seed cotton (3 maunds)	$22\frac{1}{2}$	produces ...		
	+ Ginning ...	1		Cotton (1 maund) ...	$20\frac{1}{2}$
	+ Freight on cotton ...	1		+ Seed (2 maunds) ...	4
	Total ...	$24\frac{1}{2}$		Total ..	$24\frac{1}{2}$

The fact that seed cotton of a finer variety does not necessarily fetch a higher price than a coarser variety may have an influence prejudicial to the cultivation of the finer variety. It should be remarked that pure Bani seed cotton fetches a slightly (10 to 20 per cent.) higher price than Varadi and that in the above hypothetical case the Bani is assumed to be impure. The fact that the price of seed cotton of two varieties is not proportional to that of the cotton somewhat complicates the process of cotton breeding, since valuations are made in terms of ginned cotton, which have to be translated into value per acre of seed cotton.

4. With regard to the hardiness of the plant, little need be said, as on an average of years it is included in the factor of yield per acre. It is of course only on an average of years that an opinion as to hardiness can be formed ; a new variety that in ordinary years proves much superior to the

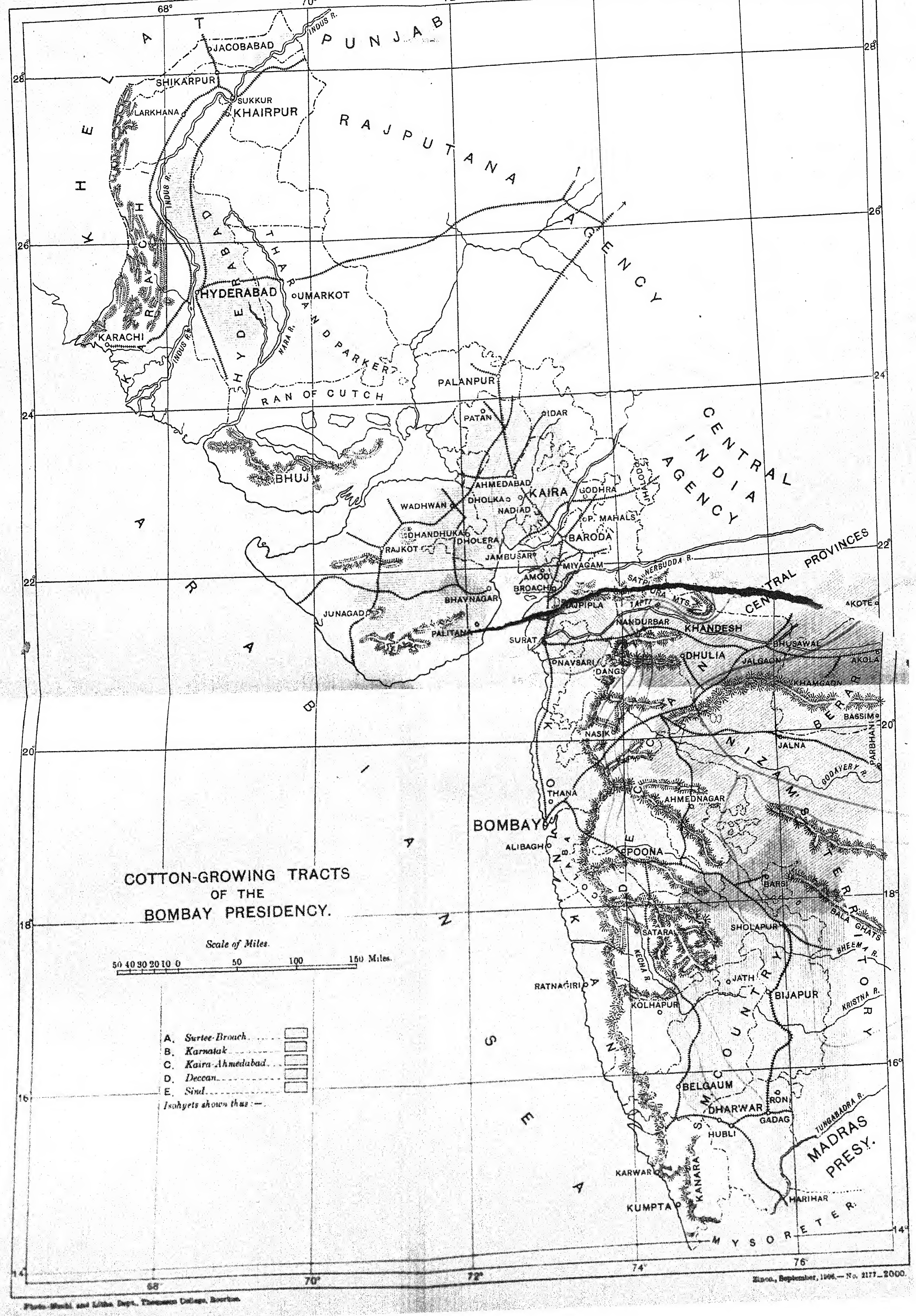
local variety may in a year of short rainfall suffer so much more than the latter as to prove worthless.

5. The method of ripening is, perhaps, of more importance in the case of cotton than of most other crops. To take an instance, in the lower Tapti Valley the inferior Varadi (or Jari) of Khandesh is grown in places where the superior Broach will grow excellently. The reason given by cultivators is that with the Khandesh variety picking extends only over a couple of weeks, while the ripening period of Broach is five weeks, so that theft is much more difficult to prevent in the latter variety. Further, the Khandesh variety ripens in November, while Broach comes to maturity in February-March ; the former crop can, therefore, be turned into cash at an earlier date than the latter, and this with the cultivator often outweighs the considerable final monetary loss incurred in the cultivation of the earlier and coarser variety.

6. From the point of view of the breeder of cotton the method of ripening involves another factor—the method in which the bolls open. This affects the cleanness of the cotton when picked ; for example, the variety 'Wagad' of North Gujarat does not open completely, and the cotton from this variety is invariably not so clean as that of the more widely opening Broach, the dirt (technically leaf) consisting of small particles of the bracteoles or leaves surrounding the boll. This factor has received special attention in America, where many of the varieties open so widely that in picking the cotton the picker need not touch the boll leaves.

II. DESCRIPTION OF COTTON-GROWING TRACTS.

7. Having thus briefly noted a few of the points to be constantly kept in view in attempts to produce a more valuable variety of cotton—that is more valuable to the cultivator—for growth under any particular set of conditions as to soil and climate, we may now consider what are the various *sets of conditions* met with in this Presidency. The greater part of the cotton-growing area of this Presidency may be defined as an elevated belt of country varying in width up to about 120 miles, extending from the Madras border in the south to the Satpuras in the north (a distance of 500 miles), with its western limit running parallel to, and 20 to 50 miles east of, the summit of the Western Ghâts, while to the east it merges imperceptibly into the immense cotton-growing tract that embraces Central India, the Central Provinces and Berar, Hyderabad and the western portion of Madras. From the region where the Satpuras interrupt at once this belt and the line of the Ghats, the former passes over the now depressed summit of the latter and appears again at sea-level on the plains of Gujarat and Kathiawar surrounding


COTTON-GROWING TRACTS
OF THE
BOMBAY PRESIDENCY.
Scale of Miles.
50 40 30 20 10 0 50 100 150 Miles.
A. Surtee-Broach
B. Karnatak
C. Kaira-Ahmedabad
D. Deccan
E. Sind
Isohyets shown thus :—
K H E L A T
PUNJAB
RAJPUTANA AGENCY
CENTRAL INDIA AGENCY
CENTRAL PROVINCES
BERAR
NIZAM'S TERRITORY
MADRAS PRESY.
MYSORE TER.
ARABIAN SEA
JACOBABAD
SHIKARPUR
SUKKUR
KHAIRPUR
LARKHANA
KARACHI
HYDERABAD
UMARKOT
THAR AND PARKER
RAN OF CUTCH
PALANPUR
PATAN
IDAR
BHUJ
AHMEDABAD
KAIRA
GODHRA
P. MAHALS
DHOLKA
NADIAD
WADHWAN
DHANDHUKA
DHOLERA
RAJKOT
BARODA
JAMBUSAR
MIYAGAM
AMOD
BROACH
BHAVNAGAR
JUNAGAD
PALITANA
RAJPIPLA
SURAT
NAVSARI
DANGS
NANDURBAR
KHANDESH
DHULIA
JALGAON
BHUSAWAL
AKOLA
AKOTE
KHAMGAON
BASSIM
PARBHANI
JALNA
NASIK
THANA
BOMBAY
ALIBAGH
AHMEDNAGAR
POONA
BARSI
SHOLAPUR
SATARA
JATH
BIJAPUR
RATNAGIRI
KOLHAPUR
BELGAUM
S. M. COUNTRY
DHARWAR
RON
GADAG
HUBLI
KARWAR
KANARA
KUMPTA
HARIHAR
KONKAN
DECCAN
INDUS R.
NARA R.
NERBUDDA R.
TAPTI R.
SATPURA MTS.
GODAVERY R.
BHEEMA R.
KRISTNA R.
KOINA R.
TUNGABADRA R.
BALA GHATS
No. 2177—2000.

the Gulf of Cambay, and still further north on those of the Indus Valley.

8. The part of this belt situated above the Ghats comprises by far the greater portion of its area. The belt between its western limit and the summit of the Ghats receives a rainfall varying from as much as 400 inches (nearly) in the rugged, jungle-covered, rice-growing western half (known variously as the Dangs, Mavals, Dongri, Mallad in various regions) to 30 inches or less in the less rugged eastern half, which grows bajri (*Pennisetum*) or jowar (*Sorghum*). This strip passes gradually eastwards into the cotton-growing plain generally known as the "Desh" with a rainfall between 20 and 30 inches. In the northern portion of the belt (Khandesh) and its below-ghât counterpart (Gujarat), the rice tract is less pronounced, and the transition to the cotton tract is more rapid, no distinct jowar-bajri zone intervening ; while still further north the rainfall is insufficient to create a rice belt at all.

9. The general appearance of the "Desh" is that of a treeless plain (1,500 to 2,000 feet above sea-level), the monotony of which is relieved only by infrequent shallow depressions generally well-wooded, in which the upper reaches of the Tapti, Godavary, Bhima and Krishna rivers rise and their (generally intermittent) tributaries flow, and by bare flat-topped hills rising abruptly either singly or in chains to a considerable height above the general level. The soil is in general of the black cotton type, but is much shallower than in the Surtee-Broach tract, often constituting a covering only a few inches thick over the underlying basalt from which it is formed. Owing to this fact and the smaller amount of the precipitation, the growing season is not long enough to allow the Surtee-Broach type of cotton to mature except in the Karnatak tract, where the rainfall, though smaller, is better distributed than in the Surtee-Broach tract.

10. The cotton belt as above outlined can be divided into five distinct tracts defined by the character of soil and season and consequently also by the types of cotton grown in them, though they naturally grade off into one another. These tracts (see map, Plate XXIV) are in the list below placed in the order of the quality of cotton produced in them, the best being placed first :—

	Texture of soil.	Annual rainfall. (inches).
(*A*) The Surtee-Broach or South Gujarat Tract ...	Black clay	33—45
(*B*) The Karnatak Tract	Black clay	23—34
(*C*) The Ahmedabad-Kaira or North Gujarat Tract	Sandy	28—37
(*D*) The Deccan Tract	Black clay	20—30
(*E*) The Sind Tract	Loam	7

The conditions of soil and climate in each of the tracts differ from those in the others, and the tracts are more or less rigidly defined by the combined character of these two factors. Further, since the whole Presidency is with regard to temperature well within the cotton zone, the only item that need be considered in relation to climate is the rainfall. The effects of temperature are complex, and will not be dealt with in this report; they are important chiefly in India in the northern continental portions.

11. The variety of cotton grown in any one of the tracts above mentioned is special to that tract and is generally the best of existing types that can be cultivated in it and, though this type can often be improved, it can seldom be supplanted. There are then two factors, namely, soil and rainfall, which in this Presidency define the type of cotton that can be grown in any particular tract. These two factors are complementary to each other in so far that a light soil under a heavy rainfall is often equivalent to heavier soil under a lighter rainfall.

With regard to rainfall it should always be kept in mind that the best cottons of the world, namely, those of Egypt and the United States of America, grow under a rainfall (or in Egypt its equivalent in irrigation) of four or five inches in each of the eight or nine months which constitute the growing period of the varieties raised in those countries. The total annual rainfall is then no criterion as to the kind of cotton that can be grown unless, *as is in general the case in India*, the amount, though varying from 7 to 400 inches, all falls within the same period—for India June to October. In India, therefore, the different cotton-growing tracts are bounded generally by isohyets (lines of equal annual rainfall), the quality of cotton varying directly with the rainfall up to the upper limit of monthly precipitation under which the cotton plant can grow at all. For instance the isohyet of 45 (that is a rainfall of 45 inches per annum) limits the growth in a southern direction of Surtee-Broach cotton. If, however, the region to the south of the limit instead of receiving its larger rainfall in the same period as the region to the north, had it spread over a longer period, it would not only grow cotton, but a cotton of a finer variety than the Surtee-Broach growth (see para. 51 below) which is our best indigenous variety.

12. Corresponding then to the graduation of fibre, as we pass down the above list, we get a diminution in the effective rainfall (or its equivalent in irrigation). By this term is meant the rainfall that can be utilized by a crop owing either to its being so distributed in time as not to run off the surface of the soil instead of sinking in, or to the soil being of a retentive nature and capable therefore of storing up the heavy short-period rainfall

for use by the crop after the monsoon is over. Thus the Surtee-Broach Tract (A) has a rainfall of 33 to 45 inches and a very retentive soil, while the Karnatak Tract (B) has a rainfall of 23 to 34 inches which also falls on a black retentive soil and in which the better distribution in time compensates for its lesser amount. Again, the North Gujarat Tract (C) has a rainfall of 28 to 37 inches, but owing to a lighter soil and a worse distribution, this is less effective than the smaller rainfall of the Karnatak Tract (B). The tracts above mentioned will now be briefly described.

(A) Surtee-Broach Tract.

13. This tract consists of the black cotton soil plain of the Surat and Broach Districts extending in a north and south direction along the shores of the Arabian Sea from the Ambika River (in Surat) to Myagaon (north of Broach)—a distance of 100 miles—and in an east and west direction from within about six miles of the sea to a distance of 20 miles inland. Up the Tapti Valley an arm of this tract extends to a point 35 miles from the sea and, after being interrupted by the line of the Western Ghats (here very low), is continued as far as Nandurbar, 100 miles from the sea; in this continuation, however, the Deccan variety of cotton is almost exclusively grown (see para. 38, Table IX). It is also continued in the form of patches across the Gulf of Cambay in the southern parts of the Ahmedabad District and in Kathiawar. The general aspect of the country is that of a flat plain relieved only by the scattered growth of babul (*Acacia arabica*), toddy palm (*Phœnix sylvestris*) and other trees. It is in no part (except its continuation up the Tapti) more than 150 feet above sea-level. Westwards the tract passes into the six-mile belt, which, owing probably to blown salt, will not mature the typical cotton of the tract; and eastwards into the hills and jungles of the Dangs which mark the line of the Western Ghats. Southwards the tract is abruptly terminated by the Ambika River, marking the northern limit of the Konkan in which the rainfall is too heavy for the growth of cotton on a large scale; and in the north passes gradually into the lighter lands of Baroda and Rajpipla States and the northern portion of the Broach District. Here commences the immense 'Goradu' (sandy) plain that extends over Rajputana into Sind and the Punjab and in which falls the third tract (C).

14. The rainfall in the Surtee-Broach tract varies in amount from 44·25 inches at Jalalpur (near Nausari) in the south to 33·5 at Jambusar in the north, and nearly all falls within the period between the middle

of June and the beginning of October, as shown in the following table :—

TABLE I.—*Rainfall in the Surtee-Broach Tract.*

	Jalalpur.	Jambusar.
June	8·80	7·23
July	17·71	12·53
August	9·43	7·32
September	6·05	4·56
October to May	2·26	2·16
Total ...	44·25	33·80

15. It is noteworthy that the quality of the cotton produced, known commercially as "Broach," improves as we proceed south, Nausari near the southern boundary of the tract producing the finest staple of the growth. The reason for this requires investigation ; it may possibly be the heavier rainfall and greater atmospheric humidity, due to proximity to the sea, that prevails at Nausari ; the character of the soil, however, though showing little variation in the field, may, if examined in the laboratory, prove to have some influence on the superiority.

16. The tract is thus seen (map, Plate XXIV) to lie between ishoyets of 33 and 45. The crop is sown in a two-year rotation with jowar (Sorghum) with the first rains in the middle of June ; and picking takes place in February-March. The cultivators are probably the most careful in India.

17. In parts of certain talukas in the north of the tract (namely, Jambusar and Amod), a coarser variety of the *Herbaceum* species, known as 'Goghari,' is also sown partly on light soil. This is doubtless fraudulently mixed with the finer growth. The survey of the areas producing this coarser variety is now in progress, and it is hoped that it will be completed in the coming season. The growing of an inferior style of cotton in an area suited to and bordering on a finer growth is a matter of considerable importance when the improvement of the staple of the tract as a whole is taken up.

18. The area under cotton in the tract in 1903-04 amounted to 98,888 acres in Surat, and 233,587 acres in Broach (including 100,868 acres in Amod and Jambusar), or a total of 332,475 acres. The yield per acre varies much, but averages about 350 lbs. of seed cotton.

B.—THE KARNATAK TRACT.

19. This tract, together with the Deccan tract (D), makes up the above-ghât portion of the cotton-growing area of this Presidency. It

comprises the part of this presidency lying east of a line drawn from Barsi to Kolhapur and thence to Harihar on the Mysore Border. It is largely contained within the Dharwar and Bijapur Districts, but embraces also parts of the Kolhapur Agency and the districts of Satara (S. E. Corner) and Belgaum (eastern two-thirds); in the Sholapur District it merges with the Deccan Tract (D).

20. In this tract there are two types of soil—in the eastern belt a stiff loam of the black cotton-soil type, in a narrow western belt a lightish soil of a reddish colour containing scattered bands of black soil; this light soil belt is confined to the southern part of the tract, being situated principally in the Dharwar District. The surface of the country is undulating, and interspersed here and there with low hills, often rounded and covered with scrub forest. These become more frequent as we proceed west from the black soil belt across that of red soil, and west of a line between Satara and Dharwar pass into the wooded and rugged rice tract (Mallad), which announces an approach to the edge of the Ghâts, whence a rapid descent of some two thousand feet takes us to the coast region (Konkan), where the heavy rainfall makes rice the only crop possible. The rainfall in the tract decreases as we proceed east from the Mallad. The character of the monsoon differs materially in the distribution through the year of the annual precipitation from that of the Surtee-Broach Tract (A), as will be obvious from the following Table, which should be compared with Table I :—

TABLE II.—*Rainfall in the Karnatak Tract.*

DISTRICT.	DHARWAR.				BELGAUM.	SATARA.	BIJAPUR.	SHOLAPUR.		MADRAS PRESDY.
Stations.	Dharwar.	Ron.	Gadag.	Hubli.	Athni.	Tasgaon.	Bagewadi.	Barsi.	Sangola.	Bellary.
MONTHS OF—										
May ...	3·0	2·01	2·51	2·57	2·96	2·26	1·71	0·90	1·24	1·8
June ..	5·88	3·87	3·22	4·05	2·86	3·61	3·25	4·33	3·79	1·8
July ...	6·00	1·81	2·69	4·76	2·22	3·84	2·33	4·54	1·80	1·3
August ...	3·94	3·45	3·45	3·50	2·09	2·77	2·70	4·64	2·85	2·3
September	4·67	5·92	5·26	3·60	5·29	5·22	7·54	8·83	7·35	3·7
October ...	5·28	2·92	5·77	5·02	4·63	4·13	3·75	2·43	3·44	3·9
November to April...	4·74	2·91	3·08	3·53	2·97	3·32	3·29	2·34	2·68	2·8
TOTAL ...	33·51	22·89	25·98	27·03	23·02	25·15	24·57	28·01	23·15	17·6
Area in thousands of acres under cotton	627				225	19	551	46		

We are here in the region receiving the two monsoons, and rain is received both earlier and later in the year than in tract A. This better distribution in time of the annual rainfall makes up for the smaller total amount and lower temperature as compared with that tract, and produces in the best parts of the tracts a staple longer and stronger than any other cotton in India not even excepting Broach ; this is also the reason why here, alone of all the many regions tried, American cotton has survived as a field crop among cultivators.

21. Corresponding to the types of soil found in this tract are grown two types of cotton known to commerce as 'saw-ginned Dharwar' and 'Kumpta' respectively. The former, the "Vilayati hutti" of cultivators, is the acclimatized American species, *Gossypium hirsutum*, and is the produce of seed introduced in 1830. It is grown almost exclusively on the red and medium and shallow black soil areas of the Dharwar District. It need hardly be said that it retains only a small semblance to its ancestor since no selection of seed has taken place, though in attempts at acclimatizing any crop, this fact is of the very first importance. The saw-ginned cotton of Hubli fetches Rs. 5 to 10 more than that of Gadag, owing probably to the better rainfall at the former place. The cotton known commercially as Kumpta and to the cultivator as 'Jowari hutti' (country cotton) is a variety of the *Herbaceum* species, that is hardly distinguishable from the Surtee-Broach plant (of which it is probably the direct descendant), except by the character of the produce which gives a lower ginning outturn of slightly longer fibre, the cotton being very thin on the seed. The outturn at the gin is much less than in the case of the acclimatized American, and it is this factor probably more than any other that has enabled the exotic to compete with the indigenous, since the yield of the former in seed cotton is no greater, if as great, while the value of the cotton itself is less.

22. The areas under these two varieties of cotton are not returned separately, but it may be stated that as a pure crop the American is confined almost entirely to the Dharwar District and to the Barsi Taluka of Sholapur, though sown mixed with Kumpta in other parts of the tract. It probably occupies about 200,000 acres. Kumpta covers a very large proportion (about 85 per cent.) of the area given in the last line of table II, and occupies about 1,200,000 acres. The areas under cotton in the chief cotton-growing talukas of the Dharwar District are given below, with a rough estimate of the percentages of the two kinds of cotton and of the red and the black variety in the soil that bears them. The yield varies very greatly, but averages about 150 lbs. of seed cotton per acre.

TABLE III.—*Acreage under cotton.*

Taluka.	Acreage under cotton in thousands.	Percentage of			
		Soil.		Cotton.	
		Red.	Black.	American.	Kumpta.
Dharwar ...	25	5	95	5	95
Hubli ...	58	5	95	5	95
Bankapur ...	39	10	90	45	55
Hangol ..	8	nil	100	nil	100
Kod ..	10	90	10	90	10
Renebennur ..	39	30	70	60	40
Karajagi ...	128	40	60	50	50
Navalgund ...	114	nil	100	nil	100
Ron ...	86	nil	100	40	60
Gadag ..	120	30	70	40	60

23. In the south of the Dharwar tract, sowing of both the varieties takes place in August-September, the north-east monsoon being there dominant. As we proceed north the influence of the north-east monsoon diminishes, and in Bijapur, Sholapur and northwards, sowing generally takes place in June-July. The rotation is either a two-year one with sorghum or a three-year one with sorghum and wheat.

24. The effect of being sown for generations in August-September appears to have caused a difference not only in the *produce* of Kumpta as compared with its parent Broach, but also a change in the *constitution* of the plant. Kumpta at Dharwar consequently not only produces seed cotton with a lower ginning outturn and a slightly longer fibre than Broach, but behaves differently from the latter variety when both are sown together at the time (June-July) when Broach is generally sown. For instance on the Dharwar Farm in 1904-1905, it was decided to reintroduce Broach into the District and see if fresh blood would not increase the ginning outturn without causing deterioration in the staple. Accordingly two plots were sown with Kumpta and Broach separately at the end of June. Kumpta lost its leaves in September and ripened in November-December, yielding 690 lbs. of seed cotton per acre, of which 20 per cent. was cotton. Broach, on the other hand, continued to grow well, and in February-March yielded 1,066 lbs. of seed cotton, of which 32 per cent. was cotton. The Kumpta was valued at Rs. 210 per candy (784 lbs.) and the Broach at Rs. 208.

It would appear from the following table of temperatures that the Kumpta variety is accustomed when three months old to be checked by the colder weather of November-December (see mean minimum temperatures in the table), and when, owing to earlier sowing, it attained this age in September,

was forced to earlier maturity by the warmer weather of that period. Broach, on the other hand, being accustomed to a still higher temperature, continues to grow normally with the result that an extremely good yield was obtained.

TABLE IV.—*Temperatures.*

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
DHARWAR—												
Mean maximum	83	87	88	92	91	86	81	83	86	85	82	80
Do. minimum	66	69	72	74	74	70	70	70	71	71	68	64
SURAT—												
Mean maximum	87	91	91	101	98	95	90	88	90	96	94	90
Do. minimum	57	59	68	75	79	81	79	77	76	72	65	61

It is hoped that the introduction of the fresh blood of the original stock into the Karnatak will result in much good. This is being done both by introducing Broach as a field crop and also by hybridizing the Kumpta with Broach.

25. The fact that in the Sholapur District, only 2·4 per cent. of the unirrigated cropped area is put under cotton, while in Bijapur nearly 20 per cent. is under this crop, is due in great part to the lighter nature of the soil in the former district, while under the same rainfall the black soil of Bijapur cannot except in good seasons mature this crop. The monsoon is also more uncertain in the former district, which seldom enjoys a good season more than once in four years. This effect of character of soil is well shown in Bijapur District itself, the talukas of Barsi and Sangola, in which the area under cotton is respectively the largest and the smallest in the district, having respectively 5 per cent. and 1 per cent. of their unirrigated cropped area under cotton. This great divergence is due not so much to rainfall as to the fact that the soil in Barsi is of a heavy black type, while in Sangola it is light and stony. Again in the Barsi taluka of Sholapur, the rainfall is greater and better distributed in time than in other talukas of the district. This is owing to the nearness of the Balaghat hills, and the cotton grown in this region is better than that of other talukas of Sholapur, *e.g.*, Sangola which enjoys a worse rainfall (see Table II).

26. This tract, as was stated above, merges into the Deccan tract in the north and east. In those parts, therefore, we find a mixture of varieties; for example, in the Barsi taluka of Sholapur and the Indapur taluka of Poona

there are grown the three varieties of Kumpta, American and the Deccan growth, in some cases as more or less pure crops, in others as a mixture containing two or all the kinds.

27. The names under which the cotton of this tract comes into the market are given in Table IX below. Westerns is the produce of the same species of plant as Kumpta, the difference between the two being that the latter is grown under better conditions of rainfall than the former and is therefore of better quality. Thus Westerns come from the Sholapur, Bijapur (except Barsi) and Belgaum districts and from Bellary (Madras), and are valued at about Rs. 30 per candy below Kumpta. A reference to Table II will show that the rainfall in these places is as much in the case of Bellary as about 10 inches below that of Hubli in the Dharwar district, which is typical of the Kumpta-growing areas. Further, much of the cotton from Sholapur and neighbouring places is still hand-ginned, which will account for 10 of the 30 rupees by which the price falls short of that of the best Kumpta.

Cotton from Miraj, though classed commercially as Westerns (see Table IX), is grown under the same conditions as good Kumpta and generally fetches the same price as that growth. Again cotton from Athni (Belgaum), though grown under the same rainfall as that from Bijapur District, is of better quality than the latter owing to the more retentive nature of the soil which is of the good black-cotton soil type.

C. The Ahmedabad-Kaira or Northern Gujarat Tract.

28. This tract, comprising the two districts named, together with the northern part of the Broach District, is somewhat remarkable in that it grows within a narrow area a number of types in a more or less unmixed condition. This is due partly to the black soil occurring in patches in the prevalent 'Goradu' of the district, partly to the use of well irrigation and partly to the cultivator's individual taste. Except in the "Bhal" or black soil area, comprising the southern half of the Dholka and the eastern half of the Dhanduka talukas, the Broach variety here known as 'Lalia' will only mature if the rainfall is supplemented by three or four waterings after the close of the monsoon; this black soil area is in reality a part of the Surtee-Broach tract, but is separated off from it by the Gulf of Cambay and thus for geographical reasons may be conveniently discussed at this stage. The tract is a part of the 'Goradu' plain mentioned above that commences in the north of the Broach district and extends to the Indus Valley. The soil is in general light both in colour and texture, and is specially suited for irrigated cultivation under wells which are very numerous. The general appearance of the plain in those parts that enjoy a rainfall of over 20 inches

is that commonly described as "park-like," fields being well wooded and separated by high cactus hedges at frequent intervals in which occur mango and other trees.

29. The average rainfall in the tract is about 30 inches, its distribution during the monsoon being illustrated by the following table :—

TABLE V.—*Rainfall in inches.*

Month.	Ahmedabad.	Nadiad.	Kaira.	Dhanduka.
June ...	4·56	5·81	4·28	4·20
July ...	10·34	12·08	11·71	10·54
August ...	8·58	11·60	9·42	6·06
September ...	6·31	6·78	6·21	5·06
October to May ...	1·10	1·28	1·11	2·02
Total ...	31·39	37·55	32·73	27·88

Passing from the cotton growing tract we are considering, the rainfall on the great 'Goradu' plain gradually diminishes, until it practically vanishes in the almost rainless Indus Valley.

30. The four chief types of cotton grown in this tract are known to cultivators as 'Wagad', 'Lalia', 'Goghari' (or 'Kanvi'*) and 'Rozi' (or 'Jeria'). Commercially they are grouped under the common name 'Dhollera', a term which is almost synonymous with that of the 'Broach (Gujarat cotton).' This growth is largely consumed locally in the mills of Ahmedabad.

31. *Wagad* is a variety of the *Herbaceum* species which differs from Broach outwardly only in the size and in the perfect dehiscence of the bolls. The cotton is not picked from the bolls while as in other growths they remain on the trees, but the dehiscing boll is plucked bodily from the plant and the seed cotton extracted at leisure in the houses of the cultivators. This boll-cotton is known as 'Kalas' and contains about 69 per cent. of seed cotton, which again contains 35 per cent. of cotton. The cotton is of fair quality, coarser than Lalia, but owing to the method of harvesting contains much dirt in the form of parts of the bracteoles and boll coverings.

Lalia is identical with the Broach variety and yields under irrigation a similar cotton ; on light soil it is almost always grown in plots of a couple of acres round wells, from which after the close of monsoon it receives three or four waterings. In one taluka (Dhanduka) it is grown unirrigated on

* The slight difference between these two varieties is possibly due only to difference in the conditions under which they are grown.

black soil often mixed with the last named variety. The rainfall (30 inches), however, is insufficient to allow the bolls to open completely, and they are often plucked whole from the tree like the Wagad with which it is mixed. The mixture fetches a better price than Wagad alone, but it is doubtful whether the pure crop would not pay better.

Goghari is grown unirrigated under the same conditions as unirrigated Lalia. It produces a coarser fibre but yields better under a short rainfall.

Rozi is the *G. wightianum* of Todaro and is assigned by Professor Gammie to *G. obtusifolium.* It approaches the *Herbaceum* species in general characteristics and appearance but is a perennial, and once sown is left on the land for three or four years. It is not sown as a sole crop in a field but as a mixture (a plant at wide intervals in every sixth row or so) with bajri and other crops. The ginning outturn is poor (25 per cent.), as is also the quality of the cotton.

32. Outside this Presidency the tract is continued into Baroda, Rajpipla, Palanpur States, Rajputana and Kathiawar. The last named Province has a large area under cotton on a variety of soils including, especially towards the west, patches of the black soil of the Surtee-Broach Tract (A) in its general 'Goradu' surface. Corresponding with the variety of soils is a variety of cottons which, while possibly fairly pure in the fields, are mixed at the presses, with the result that the reputation of the whole tract is not high. In the black soil portions, good cotton of the Broach type was formerly grown, but latterly seed of Khandesh cotton taken across the Gulf from Bombay as cattle food has been sown under the name 'Mathia.' The admixture of this short stapled variety has accelerated the process of degeneration of Kathiawar's reputation for cotton.

33. The crop is sown at the commencement of the monsoon (June) in rotation with bajri. The area under cotton in the Ahmedabad District is 300,000 acres and in Kaira 6,000 acres. The yield per acre varies from 200lbs. of seed cotton when unirrigated to as much as 1,200lbs. when irrigated.

D. The Deccan Tract.

34. This includes in this Presidency the districts of Khandesh (whole), Nasik (eastern one-third), Ahmednagar (eastern one-third) and Poona (south-eastern corner), and in Sholapur gradually merges into that of the Karnatak. In Khandesh the rainfall is derived almost entirely from the South-West monsoon, but in the southern part largely also from the North-East current. The annual precipitation varies only between 20 and 25 inches—and

exceptionally to 30 inches in East Khandesh—in the different portions, as shown in the following table :—

TABLE VI.—*Average rainfall in inches.*

District.	Khandesh. East.	Khandesh. West.	Nasik.	Poona.	Ahmednagar.	
Station.	Jalgaon.	Dhulia.	Malegaon.	Indapur.	Shevgaon.	Nevasa.
Month of—						
May ...	0·26	0·06	0·73	1·40	0·71	0·78
June ...	4·38	3·90	4·06	2·89	6·36	4·78
July ...	8·62	5·77	4·37	2·06	5·11	3·97
August ...	6·83	3·97	3·15	1·72	3·22	2·13
September ...	6·38	6·28	6·44	6·93	6·84	7·23
October ...	1·20	1·19	1·41	2·86	2·21	1·52
November to April ...	1·15	1·23	0·70	2·35	1·93	1·75
Total rainfall ...	28·82	22·40	20·86	20·21	26·38	22·16
Area under cotton in thousands of acres ...	893	395	71	11	144	

It is interesting to note that the rainfall in East Khandesh is heavier than in the Western portion of the District—contrary to the general rule for the "Desh" as a whole—and that the cotton is in consequence better in quality and greater in quantity than in the West; for instance, the cotton of Jalgaon is better than that of Dhulia (see table above) though produced by the same variety of plants.

35. The area under cotton in the districts of the Deccan Tract is given for the year 1903-1904 in Table VI, the total being 1,440,000 acres or 24 per cent. of the whole area under cotton in this Presidency (including Native States). The yield per acre varies from 100 to 700 lbs. of seed cotton.

36. The variety of cotton grown in this tract is the same as that grown under similar conditions over practically the whole of Central India, Rajputana, the Central Provinces and Berar, the Nizam's Dominions and also on the lighter alluvial soils (often under irrigation) of the United Provinces,

Punjab and Sind. The total area in India under this variety is probably, therefore, as given in the following table :—

TABLE VII.—*Area under cotton.*

Presidency.	Thousands of acres.
Bombay	1370
Central Provinces	1305
Berar	2851
United Provinces	1238
Central India	771
Nizam's Dominions	2640
Rajputana	394
Punjab and N.-W. F. Province	1294
Sind	207
Other Native States	503
	12573 or 12½ million acres.

This is about 70 per cent. of the total area under cotton in India (17½ millions).

37. The rainfall at a few places in these extra-presidential regions is given in the following table :—

TABLE VIII.—*Average rainfall in inches.*

	Jalna.	Akola.	Amraoti.	Saugor.	Neemuch.	Indore.	Jhansi.	Secunderabad.	Nagpur.	Raipur.
MONTH OF—										
May	0·8	0·2	0·6	0·6	0·5	0·6	0·3	1·4	0·8	0·9
June	7·2	5·2	6·9	6·3	3·9	6·8	4·0	3·7	8·8	10·4
July	6·8	7·8	8·8	16·8	11·2	10·4	13·6	6·0	13·3	14·8
August	5·3	6·7	7·0	11·2	19·4	7·8	10·5	5·7	8·9	12·1
September	7·5	5·8	5·3	7·3	5·5	8·1	5·2	5·2	7·8	7·7
October	3·4	2·2	1·6	1·3	1·0	1·2	0·8	3·3	2·3	2·2
November to April ...	2·5	2·3	2·0	2·6	0·7	1·2	1·4	3·0	3·0	2·9
TOTAL ...	33·5	30·2	32·2	46·1	42·2	36·1	35·8	28·3	44·9	51·0

From this table it might appear that the rainfall of Nagpur, which approximates to that of Nausari in character, should ensure a better quality of cotton than that now coming from the former tract. Here, however, the question of temperature comes in, and though the mean maximum is about the same as Dharwar, the mean minimum at Nagpur for December and January is 54° and 55° which is much below that of the Surtee-Broach Tract, and still more below that of the Karnatak Tract where, as we have seen, Broach cotton grows well.

The importance of the particular variety of cotton produced in the tract under record it is hardly possible to exaggerate in view of the large area over which it is grown, and a thorough investigation of it is of very great urgency. Owing to the enormous area annually put under this variety, a very slight increase in its value per acre would mean in the aggregate a very large increase in the total value of the growth. The lines on which this investigation should proceed are indicated below.

38. It is first necessary, however, to sketch briefly the nomenclature under which cotton, and the cotton of this tract in particular, comes into the market. In general it receives the name of the district in which it is grown, and if more detailed classification is required, the station at which it is put on to the rail for transport to the cotton markets of Bombay, Calcutta, Madras and Karachi. We thus get the following names applied to different qualities of cotton :—

TABLE IX.—*Commercial Classification of Cotton.*

Tract in which grown.	General name of the growth.	Subdivisions of the growth according to— Province or District.	Subdivisions of the growth according to— Station or Town.	REMARKS.
A. Gujarat ...	Broach or Surtee-Broach.	Broach	Miagaon and to the south about 7 others.	
		Surat	Surat, Navsari and 19 others.	
B. Karnatak ...	Kumpta		Dharwar, Gadag, Hubli.	
	Saw-ginned Dharwar ...		Gadag. Hubli.	
	Western ...		Annigeri, Bagalkot, Sholapur, Belgaum, Bijapur, Miraj and about 30 others.	In the Bombay Karnatak.
			Raichur and 5 others.	Nizam's Dominions.
			Bellary and 12 others.	In Madras.
C. Ahmedabad Kaira or North Gujarat.	Dhollera ...	Cutch	About 10 towns.	
		Northern Gujarat	About 20 towns.	
		Kathiawar	Wadhwan, Bhavnagar, Junagad, Dhollera and about 40 others.	From many of these places a variety known as "Mathia" is also obtained which is distinguished thus :— "Bhavnagar (Mathia)"

PLATE XXV.

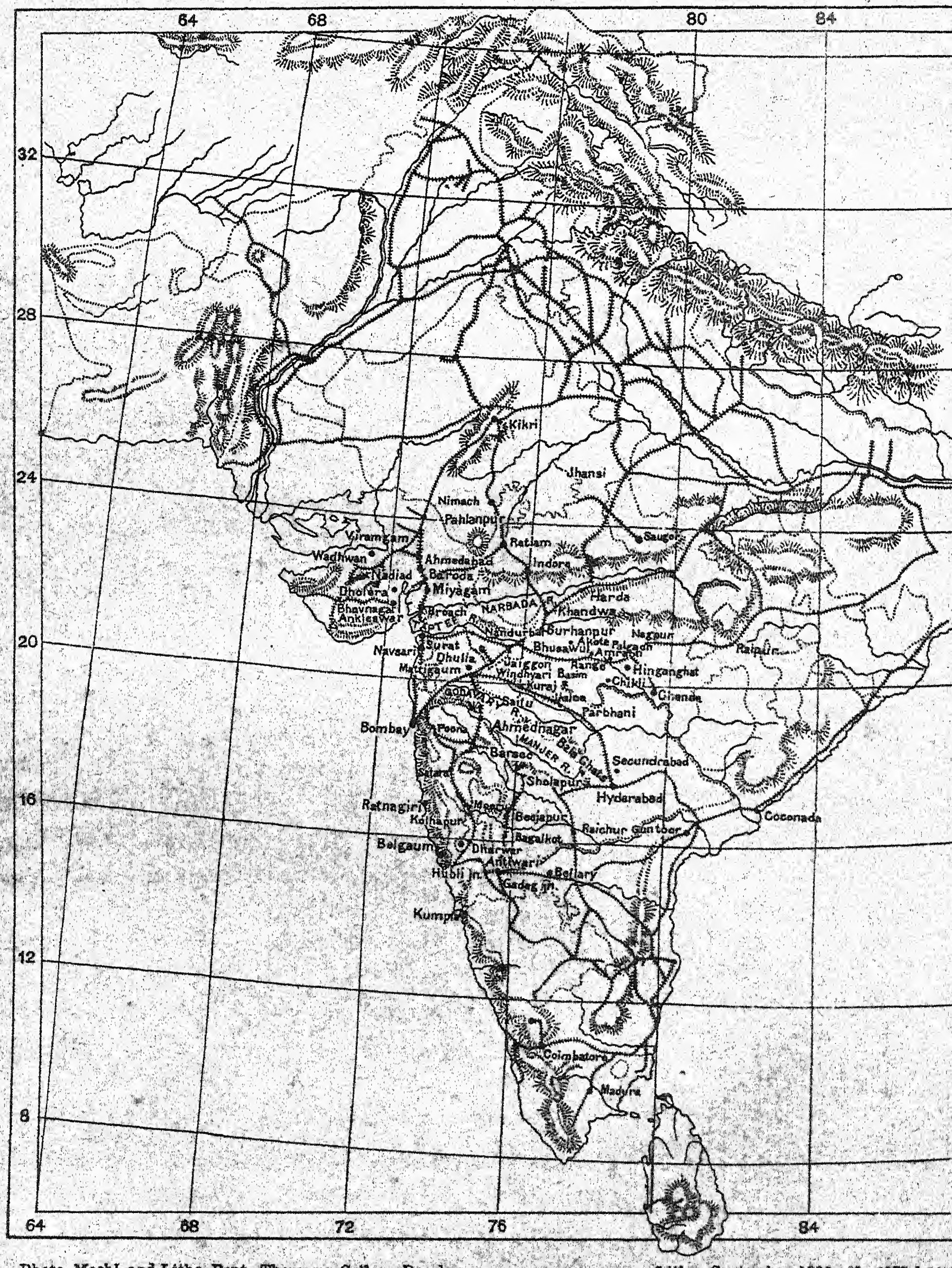


Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

Litho., September, 1906—No. 2177-I.-2500.

TABLE IX.—*Commercial Classification of Cotton.*—(Contd.)

Tract in which grown.	General name of the growth.	Subdivision of the growth according to— Province or District.	Station or Town.	REMARKS.
D. Deccan.	Oomras (or Oomrawattee)	Belati — Berar	Amraoti and 10 others.	Short staple.
		Belati — Central Provinces.	Nagpur, Pulgaon and 10 others.	
		Khandesh	Dhulia, Jalgaon & about 20 others.	Medium length.
		Khandesh. — Central India.	Indore and about 6 others.	
		Khandesh. — Central Provinces.	Burhanpur, Harda, Khandwa.	
		Khandesh. — Berar.	Akola & 20 others.	This is Oomras proper & fairly long in staple.
		Hinganghat	Hinganghat and about 2 others.	Long stapled.
		Barsi ...	Barsi and 10 others.	
		Nagar ...	Ahmednagar and 10 others.	
	Bengals. ...	Rajputana	Kekvi & 20 others	Improving in quality.
		Central India.		
Tract not treated of in this article		Bengal ...	Comilla ...	This is Bengal proper.
		United Provinces.	Cawnpore & 20 others.	
E. Sind.	Sind. Punjab.		Over 30 Stations in Sind & Punjab.	
Tract not discussed in this article.	Coconada ...		Coconada and Guntur ...	In Madras.
	Tinnevelly ...		Coimbatore and about 12 others.	Do.

39. From the table it will be seen that a variety of cotton grown in a particular tract may be known under several names commercially, though it has all been produced by one botanical variety (or one mixture of varieties) of plants; for example, Oomras and Bengals (part), Sind, Punjab are all produced by a mixture in different proportions of the same botanical

varieties of cotton. Further in the case of Berar the cotton coming from the southern part is known as Berar (proper), while the growth from the northern part and from the southern part of the Central Provinces is known as Belati and that from the northern part of the Central Provinces is classed as Khandesh. All this cotton is produced by the same mixture of varieties and, as will be shown later, the difference in quality is due to the difference in the proportions in which the varieties are grown to form the mixture.

40. The mixture of varieties that produces the cotton over some $12\frac{1}{2}$ million acres of the Deccan cotton-growing tract will now be examined in detail, and the proportion in which the constituents are mixed will be given for the few cases investigated. This mixture consists principally of four varieties which Professor Gammie has named as follows :—Four of the varieties belonging to Todaro's species *neglectum* and one of the same author's species *indicum*, the varieties being :—

Botanical name.	Cultivator's name.
(1) Gossypium neglectum rosea	Varadi.
(2) Do. do. do. cutchica ...	
(3) Do. do. vera	Jari.
(4) Do. do. do. malvensis ...	
(5) Do. indicum.	Bani.

Broadly speaking the fibre produced by these varieties increases in value as we go down the list, *G. neglectum rosea* producing the shortest staple and the lowest priced on the market, while the last species in the list (*G. indicum*) produces the cotton known as Bani or Hinganghat which, when pure, is equal to the best Broach in value and is, therefore, little inferior to middling American.

41. For the purpose of analysing botanically some of the commercial growths of cotton, specially those of the Deccan Tract, I obtained, through the courtesy of the Bombay Chamber of Commerce and Messrs. Ralli Brothers, seeds (without cotton) of the growths given in the table below. The name of the variety is that of the growth from which the seeds were obtained and not that to which the seeds when sown by me gave rise. The growth had, therefore, been classed before the seeds were sown. Owing to the inability of the fieldman to distinguish between the fourth and fifth of the varieties mentioned above, these varieties were counted as one ; it may be said that the proportion of plants of the fifth variety (Bani) was in all cases small. In future work, however, all five varieties will be counted separately.

TABLE X.—*Varieties of Deccan cottons.*

Field No. of the sample.	Name under which the seed was received.	PERCENTAGE ANALYSIS OF PLANTS PRODUCED FROM THE SAMPLES OF SEED.							Comparative price in rupees per candy of 784 lbs. in Bombay.*
		Varadi.		Jari.		American.	Broach and Kumpta.	Red flowered.	
		Neglectum rosea.	Neglectum rosea cutchica.	Neglectum vera.	Neglectum vera malvensis.	Hirsutum (American).	Herbaceum.	Arboreum.	
1	2	3	4	5	6	7	8	9	10
341	Nagpur	...	...	34·2	65·8	...	...	...	200
342	Umravati ...	43·7	19·5	23·0	11·5	2·3	...	...	185
343	Central India ...	50·9	25·4	7·3	10·9	5·5	...	...	180
344	Berar	50·6	20·7	3·5	17·3	8·0	...	...	185
345	Barsi	4·8	6·5	9·7	64·5	14·5	...	...	} 200
370	Barsi (mixed staple)...	4·2	...	11·5	60·0	24·2	...	...	
371	Barsi (good staple) ...	1·0	...	11·1	64·8	23·1	...	...	
346	N.-W. Provinces ...	42·2	23·4	21·9	12·5	...	...	...	?
347	Bhavnagari ...	...	9·1	...	7·3	...	83·6	...	?
348	Belati	64·9	14·9	6·4	13·8	...	...	...	185
349	Rajputana ...	39·4	11·5	7·7	41·4	...	...	...	?
350	Central Provinces ...	1·1	1·1	82·5	35·3	...	...	...	Probably almost as for Nagpur.
351	Western Bengal ...	83·5	2·5	11·4	2·5	...	...	...	?
352	Punjab	43·9	24·7	...	28·8	...	...	2·7	180
353	Khandwa (fair staple)	11·4	20·3	11·4	53·1	3·8	...	..	200
354	Harda (good staple) ..	3·8	0·9	33·0	62·3	...	...	...	200
355	Harda (fair good staple.	5·4	9·5	29·7	55·4	...	...	...	200
356	Dhamangaon ...	55·0	27·5	11·3	5·0	1·2	...	...	190
357	Pulgaon	92·5	6·6	...	0·9	...	...	...	190
358	Kumpta Hubli	...	...	...	...	...	100	...	225
359	Akola (good staple) ...	3·6	2·4	10·8	81·9	1·2	...	...	} 190
360	Akola (ordinary staple).	59·8	18·5	2·2	19·5	...	...	...	
361	Khamgaon (ordinary)	14·5	14·5	10·5	57·9	2·6	...	...	} 190
362	Khamgaon (good) ...	2·1	8·7	6·5	79·4	3·3	...	...	
363	Karanja (ordinary staple).	64·4	18·4	2·3	14·9	...	...	...	190
364	Karanja (good staple)	19·7	8·6	8·6	60·5	3·6	...	...	...
365	Junagarh (Mathia) ...	...	86·3	1·1	10·5	...	2·1	...	175
366	Junagarh (Dholka, good staple).	3·3	3·3	2·2	6·7	...	84·5	...	?
367	Parbhani (good staple)	1·0	3·0	19·0	55·0	22·0	...	...	200
368	Sailu (good staple) ...	5·7	0·9	9·4	80·2	3·8	..	...	} 200
369	Sailu (well up to good staple).	34·4	..	12·5	37·5	15·6	..		
370	Hinganghat (ordinary staple).	56·1	12·2	6·1	23·5	2·0	...	...	200
373	Hinganghat (good staple).	2·1	...	13·5	84·4	...	...	...	...

* The price given in column 10 is meant only to indicate the relative values of the growths as ordinarily received; the actual prices of course vary, and the ratio between any two stations may be reversed in the case of particular samples. Where two samples are from the same station, the price in the table is that of the better one.

TABLE X.—(*Contd.*)

Field No. of the sample.	Name under which the seed was received.	PERCENTAGE ANALYSIS OF PLANTS PRODUCED FROM THE SAMPLES OF SEED.							Comparative price in rupees per candy of 784 lbs. in Bombay.†
		Varadi.		Jari.		American.	Broach and Kumpta.	Red flowered.	
		Neglectum rosea.	Neglectum rosea cutchica.	Neglectum vera.	Neglectum vera Kathivarensis.	Hirsutum, (American).	Herbaceum.	Arboreum.	
1	2	3	4	5	6	7	8	9	10
374	Sind	1·2	3·4	44·2	51·2	...	...	...	190
	*Pimpalner ...	42·5	31·8	4·6	21·1	...	...	...	?
	*Nandurbar ...	22·5	36·7	8·2	32·6	...	...	...	?
	*Taloda	2·3	35·7	16·7	45·3	...	...	...	?
	*Shahada	39·7	52·9	...	7·4	...	...	...	?
	*Dhulia	40·0	44·2	2·6	13·2	...	...	...	185
	*Chopda	76·9	23·0	...	..	...	...	...	?
	*Jalgaon	73·0	16·2	8·1	2·7	...	...	...	190
	*Broach	...	...	...	...	...	100	...	215
	*Surat	...	...	...	...	.	100	...	220
	*Nausari	...	...	...	...	...	100	...	230
	*Saw-ginned Dharwar	...	...	...	...	100	...	..	215

42. A detailed examination of the table is instructive, but a few points only can be now indicated. The analysis should be compared with the figures in the last column which represent the comparative prices of the cotton usually arriving in Bombay of the growths named in the second column. It will be found that the price varies directly in almost every case with the percentage of the plants producing the better staple. This is very marked in the cases in which seeds from the same place were obtained from crops showing a difference in staple ; such instances are Barsi, Harda, Akola, Khamgaon, Karanj, Sailu, Hinganghat. In all these cases the seed from the better growth contained a larger percentage of Jari (columns 5 and 6) than of Varadi (columns 3 and 4). This is, I think, of the utmost importance, for it shows that differences of quality in many cases are due not to differences in soil, climate or methods of cultivation, but to differences in the actual

* Seed from these places was obtained from another source.

† The price given in column 10 is meant only to indicate the relative values of the growths as ordinarily received ; the actual prices of course vary, and the ratio between any two stations may be reversed in the case of particular samples. Where two samples are from the same station, the price in the table is that of the better one.

seed sown, and that therefore seed distribution can do much good. It may be urged that the ryot would grow the better staple if it paid him better. This is, however, to ignore the lack of knowledge under which the ryot labours, especially in the case of cotton. It has hitherto been found impossible to distinguish between samples of Bani, Jari and Varadi seed after ginning, and the cultivator himself certainly cannot distinguish them. The case of cotton is, therefore, entirely different from that of cereals, where the appearance of the seed tells the cultivator what quality on a harvest he is likely to obtain.

It should be noted that the quality of the Bhavnagari sample must have been above that ordinarily received in Bombay which is Mathia, while the sample (347) in the table is almost pure Broach cotton. Again the purity of the Kumpta (358), saw-ginned Dharwar (American), Broach, Surat and Nausari is all that can be desired. With regard to Hinganghat, it may be said that the crop received under this name in Bombay used to consist of pure Bani (*Gossypium indicum*), while the samples (372 and 373) analysed included only a few plants of this variety. The pure Bani cannot be had now in Bombay, being all appropriated by the mills of the Central Provinces. The price (Rs. 200) of so-called Hinganghat in Bombay is witness to the impurity of the growth, for when pure the cotton from Bani is worth as much as best Broach (say Rs. 230).

43. The growth of cotton in the Deccan Tract of India and not only of the Presidency may for the present purpose be divided into the three divisions of Varadi, Jari and Bani, according as it is respectively of a very short and coarse, of a coarse but longer, or of a fine long staple. It should, however, be understood that all these and especially the two first are now grown mixed and that the Varadi of Khandesh and the Jari of the Central Provinces are practically identical. The coarse Varadi has, in fact, replaced the original Jari in many localities, *e.g.*, in Akola (see samples 359 and 360), while both have replaced Bani to a large extent. The area now sown with pure Bani—the centre of cultivation is in the Wardha Valley lying between the Central Provinces and Berar—is not accurately known, but except around its original home is negligible.

44. It would be both interesting and extremely useful to have on record a history of the decline of the cultivation of Bani which, when grown pure, is an even more valuable fibre than Broach or Kumpta. It has been within recent years largely displaced by the coarser Varadi, a name which rightly or wrongly indicates Berar as the point of origin. Doubtless there are many cotton merchants who could say whether a pure sample of Bani is now equal to what it was fifteen years ago. This would be interesting

in view of the suggestion that the deterioration in part at least is due to the degeneration in the plant itself and not entirely to intermixture of coarser growths. So far there is no evidence in favour of this suggestion, and it is much more probable that the process of deterioration in the cotton of the district is due to the replacement, in part or bodily, of the original variety by a coarser and possibly more prolific one. It has generally been assumed that such replacement has been consciously and honestly brought about by cultivators in their own interests on finding that the value per acre of the coarser sort was greater than that of the finer. I venture to think that, although this may have been the case, it is by no means proved, and that there are two alternative methods in which respectively the cultivator or the money-lender plays a less honest and an entirely unconscious part. The whole question turns on the relative yields in both seed cotton and cotton of the finer and coarser varieties. The only evidence I have on this point is that furnished by the Government Experimental Farms at Nagpur, Cawnpur and Dhulia, which is as follows :—

Name of Farm.	Period of experiment.	Variety.	Average Yield per acre in lbs.		Percentage of Cotton in Seed Cotton.
			Seed Cotton.	Cotton.	
Cawnpore ..	5 years 1895—99 ...	Bani ...	580	145	25
		Jari ...	769	246	32
Nagpur ...	5 years 1892—96 & 98	Bani ...	216	54	25
		Jari ...	206	66	32
Dhulia ...	1 year 1905—06 ...	Bani ...	670	167	25
		Jari ...	698	209	30

At Cawnpore there can be no doubt that the coarser Jari pays better under the system of planting practised than Bani ; whether this system is equally fair to the two varieties is a question that can only be decided by experiments in which each variety is sown and cultivated in the method best suited to it. At Nagpur, even if we take the price of Bani seed cotton to be no higher than that of Jari, though it is not unusual for it to be 20 per cent. higher, the cultivation of Bani is the more paying. The same remark almost applies to the one year's experiment at Dhulia. We may then conclude that in certain districts of the Deccan Tract, the cultivation of Bani still pays the cultivator better than that of Jari.

45. The cultivator is not, however, a free agent with regard to the crops he can sow, which are often decided by the dealer, and his point of view must, therefore, be considered. Though the yield per acre of seed cotton may be the same for both Bani and Jari and, therefore, even supposing

that Bani seed cotton sells only at the same rate as Jari seed cotton, the two are equally paying to the cultivator, but the case is quite different when we consider the cotton alone, and it is with this form of the crop that the dealer is chiefly concerned. Taking the above figures for Nagpur, we find the yield per acre of cotton to be in favour of Jari which yields 20 per cent. more than Bani. This increase is only just sufficient to counterbalance the smaller price of Jari cotton (in contradistinction to seed cotton) as compared with Bani. If, however, the dealer can sell his Jari cotton at the price of Bani, he gains in dealing in the former commodity. This he can do to a certain extent by judiciously mixing a little Jari cotton with a large bulk of Bani. Having once tasted the sweets of illicit gain, the descent to Varadi was not only easy but inevitable, and by dint of deluding himself he was deluding some one else, the cultivator (or his money-lender), who would progress in his unrighteousness and add more Varadi. It may be argued that when the practice of admixture becomes generally known, buyers would decline to be further defrauded and would give for Varadi only the price of Varadi whether it was called Bani or not, so that a return to the cultivation of Bani would ensue if this were more paying than the honest cultivation of Varadi. There are, however, difficulties in the way of this return. The first is that to obtain the intrinsic value of a sample of cotton, there must be sufficient cotton of the same class to make a market. Suppose, for instance, in a Varadi growing tract, an enterprising cultivator grows five acres of Bani and obtains 1,000 lbs. of seed cotton (Kapas). This quantity would have to be ginned separately in the first place, and when ginned would not be sufficient to form a bale. The cultivator would probably get less per maund for his finer Kapas than he would get for the coarser local growth, since it would be bought on the basis of Varadi cotton (in contradistinction to seed cotton) and the percentage of cotton in it would be less. Combination among cultivators would overcome the difficulty, but this is at present non-existent in India. The second difficulty met with in an attempt to resuscitate the cultivation of a finer growth is that a district, having once obtained an evil reputation, cannot for some time receive a proper reward for a reform in its conduct, so that its return to respectability can only be made at a price, *viz.*, the selling of a superior variety for some time at a price little, if any, above that of the inferior variety ordinarily grown.

46. If the cultivator's and dealer's honesty must, like Cæsar's wife, be above suspicion, the following is put forward as an alternative to the usually accepted view of the method of displacement of Bani by Varadi. There is evidence tending to prove that in some districts the cultivation of Bani is

more paying than that of Varadi, though the yield per acre of the latter is the greater. Suppose, therefore, that the cultivator of a district wishes to continue to cultivate Bani as a pure crop, he may only be able to raise a mixture through contamination of the seed at the gin. Suppose, further, for the sake of illustration that a plant of Varadi produces twice the number of seeds of a plant of Bani. Then, if we have one plant of Varadi as a weed in a field of Bani and this is not removed, the resulting seed when sown will give two plants of the Varadi to the acre of Bani, the following season four plants, and so on. The percentage of impurity would thus, if unchecked, increase from year to year in geometrical progression up to the point of complete substitution of the weed for the original crop. A cultivator may thus unconsciously allow Varadi to displace Bani in his fields, even though he knows that the latter would pay him better. If the cultivator had the knowledge and initiative required for the separation of the two varieties—not to the uninitiated very different from one another—there would, of course, be no possibility of his unconsciously decreasing his income in this way. Cultivators, however, as a rule, know much less of the varieties of cotton than of such crops as sorghum, wheat and the like, the excellency or otherwise of the produce of which is more or less brought home to them very practically in their daily bread. On the above supposition as to the relative number of seeds produced by single plants of the two varieties, it is easy to show that it would take only sixteen years to convert fields of Bani containing one Jari plant per acre into fields containing nothing but Jari. The supposition, however, assumes a greater disproportion between the fields of Jari and Bani than is ordinarily found. The following is a closer approximation in actual facts. Taking the rates of seed cotton to be Rs. 7 and Rs. 8¾ (per 80 lbs.) for Jari and Bani respectively, we see that the two varieties are equally paying *to the cultivator* if Bani yields 120 lbs. of seed cotton per acre when Jari yields 150 lbs. Of the 120 lbs. of Bani 75 per cent. or 90 lbs. is seed and of the Jari 68 per cent. or 102 lbs. The ratio of the number of seeds produced by a single plant of Bani and Jari would seem, therefore, to be as 9 is to 10 and not as 1 to 2. The problem is, however, complicated by the fact that though single seeds are of equal weight in both cases, a greater number of seeds of Bani should probably be sown per acre than of Jari to secure the best results. This is a point that will be tested.

47. From the above remarks it will be apparent that much more experiment is necessary before it can be stated that the cultivation of Jari is invariably more paying than Bani under the same set of conditions *when the produce in each case fetches its intrinsic value.* Experiment along these

lines has been started at the Government farm at Dhulia. Other experiments, there being carried out with a view to the improvement of the three agricultural varieties of Varadi, Jari and Bani, include attempts to increase the yield per acre and the ginning outturn of Bani by hybridization and selection, and to improve the staple of Varadi by the same means.

48. The cotton of this tract is sown in June and matures in November-December. The rotation is a two-year one with bajri on light soils, or sorghum on heavier ones, alternating with cotton.

E.—The Sind Tract.

49. The fifth cotton-growing tract of the Presidency can be dealt with very briefly. It is not here possible to go thoroughly into the possibilities of this tract as they are dominated by the question of irrigation. Briefly the canals of Sind may be divided into two classes, inundation and perennial; of the latter there is, properly speaking, only one, the Jamrao, which commands an area of 7½ lakhs of acres, of which one lakh is annually placed under cotton. On canals of this kind providing water all the year round, it has been proved that Egyptian cotton of a quality only slightly inferior to that of Egypt itself can be grown and will yield as much seed cotton as the local variety and is worth twice as much. It must be sown in March or April so as to mature before frost occurs in January.

50. On the inundation canals, on the other hand, water is available only during the period of inundation of the Indus. This is about 3½ months (June to October), that is, about the same as the period during which rain falls in the Presidency proper. The local variety of cotton all over Sind, except in the Upper Sind Frontier, is identical with that described above under the name Varadi or Jari, which here, however, under the influence of irrigation yields five to ten times as much per acre, averaging about 600 lbs. of seed cotton and even reaching 1,600 lbs. It might be argued that even under the inundation canals, since the quantity of water available is at least equal to that falling as rain in the Surtee-Broach Tract, the superior cotton of the latter tract might be grown in place of the inferior Varadi. Here, however, the question of temperature comes in and, where the cotton cannot be sown before June, it is necessary to grow an early ripening variety, because frost generally occurs in January. Jari ripens in five months and Broach in eight, and it is therefore uncertain whether Broach would mature on inundation canals in Sind. What is required, therefore, for a radical improvement of the cotton in Sind is an improvement in the irrigation, and this is now under consideration by the Irrigation Department

in the form of a large perennial canal taking off at Rohri and running as far as Hyderabad.

SUMMARY.

51. The quality of cotton is in general directly proportional to the length of the period of growth of the plant producing it. Thus Egyptian matures in nine months, American in eight, Broach in eight, Jari in five and-a-half. The length of this growing period depends on (1) the amount of annual rainfall ; (2) its distribution ; and (3) the retentivity of the soil. Excepting the Karnatak Tract the rainfall in this Presidency all falls between the middle of June and the end of September, three and-a-half months. If the soil is deep retentive black soil, the growing period of the plant extends for as much as five months after rain has ceased (Surtee-Broach Tract) ; if less retentive (Deccan Tract), for only three months. The Deccan Tract, therefore, cannot in general produce as long a staple as the Surtee-Broach Tract even if the rainfall were equal in both.

52. The five cotton-growing tracts of this Presidency are :—

A. The Surtee-Broach Tract, with a deep retentive soil which, under a rainfall 34 to 45 inches falling in 3½ months, can support our best indigenous cotton, though this requires eight months for maturity.

B. The Karnatak Tract, also with a black retentive soil which, under a smaller rainfall of 23 to 34 inches distributed over five months, can support an indigenous cotton almost if not quite equal in quality to Broach, and which at the expense of its ginning outturn takes a month less to mature ; on the lighter soils American cotton also grows well under the better distributed rainfall.

C. The Ahmedabad-Kaira Tract, with a light soil and a rainfall of 28 to 37 inches falling in three and-a-half months ; owing to a given quantity of rain being less effective on light than on heavy soil unless well distributed throughout the growing period, this tract cannot produce an annual cotton equal in quality to the two former tracts.

D. The Deccan Tract, with soil varying from light to a thin black clay which, under a rainfall of 20 to 30 inches all falling within 3½ months, can produce either a coarse cotton (Jari) or a fine one (Bani) ; here again a finer variety matures in the same time as a coarser one (or about a fortnight later) but only at the expense of the ginning outturn.

E. The Sind Tract.—This tract is dependent on irrigation and can grow Egyptian cotton where the canal is perennial, and it is possible to sow early, so that it can produce the finest cotton known to commerce, except Sea Island (only grown over a small area in America). Where, however,

irrigation is only possible during the period in which the Indus is in flood (June to October), the quality of cotton that can be grown will probably even when improved to the utmost not be superior to that of the Surtee-Broach Tract, and is actually now equal only to that of the Deccan Tract.

III.—IMPROVEMENT OF COTTON.

53. A short account of what has been, and is now being, done in this respect in this Presidency is given below. The possible methods by which the cotton of any tract may be improved are :—

(*a*) Hybridization between two varieties and subsequent selection ;
(*b*) Selection (plant to plant) of the local growth ;
(*c*) Exchange of the variety in one tract for that grown in another ;
(*d*) Introduction of varieties foreign to India ;
(*e*) Improvement in the methods of cultivation.

HYBRIDIZATION.

54. Hybridization is often referred to in the public press as if when this is once done the whole question of improvement of cotton is at an end. That this is not the case will be obvious when it is stated that of the progeny of a cross between any two varieties of cotton, some may be better, some equal to, and some worse than either or both the parents. Hybridization unless followed by extremely careful selection will lead to nothing, while selection alone without hybridization can often bring about a considerable improvement as will be shown later.

In 1901 Mr. Mollison caused crosses to be made at Poona between a large number of the Indian varieties of cotton. These were carefully examined by me in 1903 and transported, as far as farms were available, to the districts to which they appeared severally to be most suited. It need hardly be said that it is impossible to rear at Poona a variety of cotton intended as an improvement on that of the Surtee-Broach variety or at Surat on that of the Khandesh variety, for when transferred to their final home all kinds of changes may occur. It is necessary, therefore, to experiment in the tract in which the cotton is intended to be grown. Corresponding to the five tracts into which the cotton-growing area of the Presidency is divided above, we have now experimental farms at Surat, Dharwar, Nadiad, Dhulia and Mirpurkhas, situated respectively in tracts A, B, C, D and E. These farms were established in the following years, *viz.*, 1897, 1904, 1903, 1905 and 1904. It will be apparent, therefore, that the

Surat Farm alone has been established long enough to secure even approximately definite results, and on that farm unfortunately the past two seasons have enjoyed less than half the average annual rainfall. The hybrids have, therefore, been growing under unfavourable climatic conditions, and it is further impossible to see how they will behave under a normal monsoon. As, however, the ordinary growths with which they have been compared in value have grown under the same unfavourable conditions, it is thought that indications of the real relative values of the hybrids and the local growths have been obtained.

55. Further, it is to be noted that it takes about five seasons before a hybrid will come "true to seed"; that is, a hybrid seed produced in 1901 and sown in 1902 will not until 1906 produce plants, the seed of which will all give rise to plants similar to one another. We are, therefore, not yet in possession of such hybrids, but those produced in 1901 will give rise this season (1906-1907) to a new variety.

56. Moreover, hybrids grown on the Surat Farm which, for three seasons have shown promise of giving rise to improved varieties, have deteriorated considerably during the past season, and of the many that have been bred and carefully selected only one (No. 1027 A) is now promising. Whether this deterioration is permanent or due merely to being grown for two seasons under less than half the normal rainfall, further experience alone can prove.

57. It would serve no useful purpose to give a history of all the crosses produced, many of which have already been abandoned. This history of three is, however, given as showing the method adopted, and the uncertainty of results.

It will be seen then that extremely careful selection is the only means of obtaining any results at all. Had the hybrid No. 1027 not been very carefully examined, the hybrid No. 1027A, which has been valued at a rate as high as 20 per cent. above fine Broach, would not have been obtained. It should be added that another valuation denotes only 8 per cent. improvement; owing to the small amount of cotton so far produced, a true and reliable valuation is impossible until next year. With regard to this hybrid 1027A it can only be said that if it does not deteriorate it will be worth many times more than the whole expenditure on the Surat Farm since its establishment. It is, however, hoped that, so far from deterioration occurring, a further improvement will be obtained by continued careful treatment.

58. Since hybrids on other farms, *viz.*, Dharwar, Nadiad, Dhulia and Mirpurkhas, have not been in existence long enough to become fixed in type, it is nnecessary to give details of them here. It can, however, be stated

TABLE XI.—*History of Hybrids.*

No. of hybrid.	Name of Parents.		Year.	Percentage of fibre in seed cotton.	Approximate percentage value above fine Broach.	Remarks.
	Female.	Male.				
1016	Broach	Kumpta ...	1901	......	...	Cross made at Poona.
			1902	......	...	Grown at Poona.
			1903	27·77	— 1·8	Grown at Poona and selected.
			1904	33·3	21·9	Grown at Surat and divided up into three subdivisions according to quality of fibre, habit of growth and the like.
			1905	28·7	— 9·4	Grown at Surat. All these divisions show marked deterioration.
				33·2	?	
				32·1	—11·3	
1027	Goghari.	Kumpta ...	1901	......	...	Cross made at Poona.
			1902	......	...	Sown at Poona.
			1903	36·9	...	Sown near Ahmedabad.
			1904	39·2	7·3	Sown at Surat and subdivided into 4 classes.
			1905	37·3	—11·3	Grown at Surat; all 4 classes have deteriorated.
				37·2	?	
				35·6	?	
				38·8	—15·1	
1027A	Goghari	Kumpta ...	1904	35·5	14·6	A single plant of the hybrid 1027 was selected in 1903-1904 as giving a superior fibre. The seed of this was sown separately in 1904 under the number 1027A and again in 1905.
			1905	34·0	18·9	

that there is no reason why an improvement should not be obtained at least equal to that obtained at Surat.

SELECTION.

59. The selection of particular plants among the local growth has not in India received the attention that it deserves. As stated previously, the cultivator has not the knowledge necessary to enable him to differentiate between two cotton plants when the difference between them is only that one is slightly more prolific or produces a slightly better fibre than the other, this difference not being potent as it is in the case of jowar, bajri, wheat and some other crops. That much can be done in this way will be obvious from a reference to Table X, which shows that a crop of Jari consists of a mixture of varieties, and that the produce depends on the proportion in which these varieties occur in the mixture. The method can,

however, be utilized in the case of pure crops, such as Broach. As an instance of this, it may be mentioned that, while showing a casual visitor round the Surat farm and wishing to illustrate the difference in staple between Broach and another variety of cotton, I picked a sample of Broach haphazard from the nearest plant in the field, and was surprised to find that it would not serve the purpose intended as it was much better than the average of the crop. The seed from the tree thus accidentally discovered was picked and sown separately, with the result that it produced in the season just past a fibre valued at 5 per cent. above cotton of the same variety grown on the same ground from ordinary seed. This process of selection is now being carried out on all the farms of this Presidency, and especially at Dharwar seems likely to lead to permanent results with the acclimatized American variety, since in this variety there is much variation from plant to plant. Owing, however, to the total failure of the monsoon in the tract during the last year, no definite results have been obtained in the short period (two seasons) during which the farm has been working.

Exchange of Varieties.

60. The limits are narrow within which an exchange of variety from one cotton-growing tract to another can take place. The growing of the Surtee-Broach variety in the Karnatak Tract appears, however, likely to lead to good results, but further experiment is needed. During the last two seasons it has been grown on the Dharwar farm side by side with the local indigenous variety, 'Kumpta,' with the following results :—

Table XII.—*Kumpta and Broach Cotton.*

Variety.	Yield in seed cotton per acre.		Percentage of fibre.		Rainfall in inches.	
	1904-05.	1905-06.	1904-05.	1905-06.	1904-05.	1905-06.
Kumpta ...	690	356	26	25	26·93	12·57
Broach ...	1,066	346	32	30		

It will be apparent that even if the Broach variety does not give a larger yield of seed cotton per acre than Kumpta, yet owing to the higher ginning outturn of the former, its value per acre is at least 20 per cent. greater. It is interesting to note that the percentage of fibre in the seed cotton of both varieties is lower in a year of small rainfall, and that the Broach variety when grown in Dharwar has a smaller percentage than

when grown in its own tract where it is ordinarily about 33. Further details will be given later as to the effect of moisture on the ginning outturn. It is immaterial whether the Broach variety deteriorates or not by continuous growth in the Karnatak so long as it gives a larger yield, since it would be no difficult matter to organise a biennial or triennial distribution of seed brought from Surat in country boats to Mormagoa.

61. Another instance of an exchange that is being tried is Bani, which is being grown side by side with the local variety Jari at Dhulia. These are, however, varieties from different parts of the same tract. As the farm has been worked for only one season and that a poor one, nothing definite can be said as to whether this is likely to succeed or not. The result in the past season was that Bani yielded 670 lbs. of seed cotton per acre, while Jari gave 698 lbs.

Introduction of Foreign Varieties.

62. The foreign varieties that have been introduced with some success in the past may be divided into two classes, *viz* :—annual and perennial (or tree cotton). Taking the annual varieties first, we find that in 1830 American Uplands seed was introduced and sown in large quantities in the Dharwar District, and it survives to-day in that District, but in a greatly degenerated form. It has also been tried in the Surtee-Broach and Deccan Tracts, but it is only in the Karnatak Tract that it remains as a field crop among cultivators ; the cause of this was given above in the description of that tract. Nothing further need be said except that there is reason to believe that if new seed be now introduced and *carefully selected*, plant by plant, acclimatization may be accomplished at a smaller cost in deterioration of the staple. This process is now being carried out on the Dharwar farm.

63. Recently in the year 1904 I grew Egyptian cotton at Dhoronoro in Sind, the results of which are given in Table XIII.

The produce was valued in Liverpool at a little less than Egyptian grown cotton of the same varieties. In the year just past about 1,500 acres were sown partly with the Metaffifi and partly with the Abassi varieties. The yield over large areas on good soil free from alkali was about 1,000 lbs. of seed cotton per acre, and would have been greater except that owing to late sowing the crop was damaged by frost. During the spring of the present year, the seed of the Abassi variety for about 6,000 acres was distributed to zemindars, and there can be no doubt that it will pay the cultivator much better than the local Varadi variety when grown under the same conditions, being valued at about twice the price of the latter, and the yield being more rather than less. The growth of Egyptian cotton or any other

TABLE XIII.—*Egyptian Cotton.*

Name of variety.	Time of sowing.	Interval between waterings in days.	Yield per acre of Seed Cotton.
Yannovitch	April ...	20	872
	Do. ...	15	1,174
	May ...	30	805
	Do. ...	30	1,046
	June ...	20	704
	Do. ...	30	684
Abassi	April ...	15	1,018
	Do. ...	20	907
	June ...	15	940
	Do. ...	20	519
Metaffifi	April ...	15	1,489
	Do. ...	20	1,257
	June ...	15	1,196
	Do. ...	20	744
	Do. ..	15	815
	Do. ...	15	364
Ashmouni	April ...	15	1,227
	Do. ...	20	972
	June ...	15	899
	Do. ...	15	900

variety with a long period of growth is restricted to those parts of Sind where perennial irrigation is possible, since if it can only be sown when the river rises in June, it cannot mature before the frost of December-January. Many attempts have in the past been made to grow Egyptian cotton in Sind and elsewhere, and it is probable that in Sind it was frost that caused uniform failure. This was certainly the case with a small plot I myself saw at Mirpurkhas in the autumn of 1903 ; the crop, having been sown in July, was totally ruined by frost in December and yielded no produce at all.

64. Further in the coastal region of Sind where the air is always damp, Sea Island cotton could be grown if perennial irrigation were available. An experiment on the Karachi sewage farm, kindly made at my suggestion by the Chairman of the Karachi gardens, gave the following results :—

TABLE XIV.—*Sea Island and Egyptian Cotton.*

Variety.	Yield per acre.
	Lbs.
Egyptian Abassi	377
Sea Island	427

The valuation of the produce has not yet been received, but the Sea Island cotton must be worth about 30 per cent. above even Abassi.

65. With regard to tree cottons, little can as yet be said, though experiments on two different species give promise of success. These species are in all probability *G. peruvianum* and *G. barbadense* (of some authors); the nomenclature, however, of the whole genus is complex. The former species yields the fibre known as "rough Peruvian," while the latter is apparently not cultivated as a field crop in any part of the world; it may be identical with the plant known as "Bourbon," and yields a smooth cotton of long staple somewhat similar in style to Egyptian, but not so long, while rough Peruvian is, as its name indicates, a rough cotton, but is also very long. Exact valuation of large quantities of these two cottons have not been as yet obtained from England, but small samples have been valued at more than 20 per cent. above fine Broach. It remains to ascertain by experiment the yield per acre that these two varieties will give. This is now being done with the species Barbadense in the Ahmedabad-Kaira Tract and with the "rough Peruvian" in the Karnatak Tract, the varieties appearing from experiment to be suited to these tracts respectively. It is possible that the former variety may require irrigation in its first year, but with a normal monsoon it may be able afterwards to pass through the hot season without this help. It appears to be extremely prolific as grown on the Nadiad farm and on a large private plantation started a year ago in the Palanpur State. The area on the Nadiad farm is not large enough to allow of the yield being calculated, but is being increased during the present season; the first crop is now being picked in the case of the other experiment with this species.

With regard to rough Peruvian, which seems specially suited to the Karnatak Tract, experiments are now being conducted on the Dharwar farm. It appears to thrive well on poor stony land which cannot be put under ordinary crops, and even under the deficient monsoon of the past season ($12\frac{1}{2}$ inches instead of 34) has survived and produced a fair amount of an excellent quality of cotton. The area is being increased to a size that will allow of testing the yield per acre.

The best method of cultivating these tree cottons is also being investigated; probably a wide spacing, say 5 feet every way, will prove the best, the intermediate area being cultivated, at least while the plants are small, with low growing crops such as some of the pulses. Further there are indications that these tree cottons will respond to certain manures more readily than the annual varieties, and experiments on this point will be commenced as soon as the plantations are well established.

Improvement in Methods of Cultivation.

66. It is often stated that the poor quality of Indian cotton is due in part at least to the primitive method of cultivation employed. While this may be true to a certain extent in the case of districts that are backward agriculturally, it has been shown above that this inferiority is due on the whole, first, to the character and amount of the rainfall, and secondly, to the fact that plant to plant selection has never been known. Further, it is often assumed that the liberal application of manure will improve the quality. That this is far from true the figures below will show. In the past season (1905-06) cotton was grown on the Surat farm on plots which two seasons before had received a liberal dressing of manure. It will be noticed that not only the quality, but also the quantity, from the manured plots is much lower than from the unmanured.

Table XV.—*Cotton Manuring.*

Variety of cotton.	Yield in lbs. per acre of seed cotton.			Valuation of cotton in rupees per candy (784 lbs.).		
	Manured heavily.	Manured less heavily.	Unmanured.	Manured heavily.	Manured less heavily.	Unmanured.
Goghari ..	68	38	149	185	210	215
Broach ...	83	28	162	215	260	265

The effect of the manure applied two years previously is somewhat remarkable, even when the short rainfall (20 inches instead of 42) is taken into account. Manure, after it has been applied to the soil, really forms part of the soil, and it was stated above that soil and rainfall are in a great part complementary. Had the monsoon not failed, it is probable that the above results would at least not have been so marked and possible that they might have been reversed.

67. The effect of water on the soil is the exact opposite of that above given for manure, but here again the abnormal season has exaggerated the effect. The results were obtained in the past season on the black cotton soil of Surat Farm on adjacent plots, one of which received waterings after the monsoon, while the other received none. The quality and yield are indicated in the folowing table:—

Table XVI.—*Irrigated Cotton.*

Variety of cotton.	Yield per acre in lbs. of seed cotton.		Valuation of cotton in Rs. per candy of 784 lbs.	
	Irrigated.	Unirrigated.	Irrigated	Unirrigated.
Broach	420	128	258	230

The effect of watering on the percentage of cotton in seed cotton is indicated by the following results obtained on the light soil of the Ahmedabad district :—

TABLE XVII.—*Irrigation Cotton.*

Variety of cotton.	Percentage of cotton in seed cotton.	
	Irrigated.	Unirrigated.
Wagad	35	32
Lalia	40	35

68. The conclusion to be drawn from these data is that the quantity of manure applied must be regulated by the quantity of water that the crop receives in the form of rainfall or irrigation or both combined. It may further be stated that of the two—water and manure—the one of which the want is by far the greater in most parts of India is water. If water was available in the hot weather, it would be possible by the growth of leguminous crops to make up for the general loss of manure by burning. The water that falls as rain on the soil in the cotton-growing tracts of this Presidency is husbanded by the cultivator to the greatest possible extent by frequently stirring the surface soil between the growing plants. Experiments have not yet been conducted to see whether the common practice of applying to black soil about ten tons of cattle manure per acre every five or seven years can be improved on, or whether this quantity of manure is indeed the correct amount and that corresponding to the rainfall received. A series of plots has now been started on the Surat and Dharwar Farms that will determine this point.

69. Artificial manures have not hitherto received a thorough trial, though experiments with them commenced two years ago on the farms of this Presidency. So far there is little indication that they can be advantageously applied to cotton or any of the common field crops, but here again the shortage of rain may have produced an effect exactly opposite to what would result in a season of normal rainfall. Experiments in the effect of deeper tillage have also just been started, but it is as yet too early to make any statement as to results, except that it seems possible that some improvement may be brought about by this means.

70. With regard then to improvement in the methods of cultivation, it can be said with certainty that in the best cotton-growing areas of the several tracts, it is only exceptionally that such is possible, and that the

methods in use are *as far as we yet know* those that under the rainfall received give the best results. One other item in the method of cultivation besides manure and irrigation is receiving special attention, and that is the time of sowing. This is fixed in all tracts, except the Karnatak, by the first fall of rain. In the Karnatak, however, though the monsoon commences in May, sowing of cotton does not generally take place until August-September, and on the Dharwar Farm experiments are being conducted in which sowing takes place in June-July. In the year 1904-1905 when the monsoon was normal except that the late rains were scanty, the early-sown crop of both Kumpta and American gave not only an increased yield but also a better quality of fibre. The results are given below :—

TABLE XVIII.—*Early and late sowing.*

Time of sowing.	Variety.	Yield in lbs. per acre.		Valuation of Cotton in Rs. per candy of 784 lbs.
		Seed Cotton.	Cotton.	
June—July	American ...	969	310	205
	Kumpta ...	690	179	219
August ...	American ...	371	118	190*
September ...	Kumpta ...	551	143	203

It will thus be seen that early sowing resulted in an increase of Rs. 7 and Rs. 10 of the value per acre of the Kumpta and American varieties respectively.

CONCLUSION.

71. From the statements above made it will be seen that progress has been made in the introduction of foreign varieties especially of Egyptian cotton into Sind, while in the case of indigenous varieties at least one extremely promising hybrid has been reared on the Surat farm and will be distributed so soon as sufficient seed has been grown. With regard to the improvement of indigenous varieties, it must not be expected that progress will be made *per saltum* either in selection or in this process aided and accelerated by cross fertilization. Under the best circumstances and with an unlimited amount of the most highly trained assistants, it is impossible to obtain a fixed type from a cross within four seasons of the date of the creation of the cross, and in field experiments on a large scale and with a very limited amount of assistance, it takes at least five seasons. This period must, therefore, elapse before the value of a hybrid can in many cases be accurately

* On the black soil of the farm the quality of American is Rs. 5 or 6 less than on a light so

judged. The great desideratum in carrying out the work of selection is a sufficiency of trained men. An attempt is being made to train men who shall become capable by accumulated individual experience of performing the routine work of selection and hybridization in a reliable manner. Knowledge in all agricultural matters is so largely a matter of individual experience that the special work of any one man cannot be taken up by another who, while possibly more highly trained generally, must accumulate his special experience before he can be of any value. It is only by a division of labour and specialisation of this kind that any efficiency can be attained. An ounce of practice in agriculture is worth several pounds of theory, and the value of experience which is here synonymous with practice cannot be transmitted on paper, though results actually obtained by means of it may. The above facts will indicate that it is yet early to look for results from hybridization on such newly established farms as those at Dharwar, Dhulia and Mirpurkhas. In the matter of methods of cultivation and transfer of seed from one locality to another, much light has been thrown by the survey of the conditions obtaining in the different cotton-growing tracts and by experiments especially on the Surat and Dharwar farms.

72. Taken as a whole, the work of the Department with regard to cotton during the past three seasons must be looked upon as merely preliminary, but it is thought that the chief lines along which work is to be done in the various cotton-growing tracts have been discovered, and these have been briefly sketched above for each tract.

ASSAM RUBBER AND ITS COMMERCIAL PROSPECTS.

By HAROLD H. MANN, D.SC.,

Scientific Officer to the Indian Tea Association.

THERE is no tropical product whose culture is calling forth at the present time such great energy and at the same time such great hopes as India rubber. Until recent years, it was entirely a jungle product, and was nowhere actually cultivated, the forests of Brazil, Central America, West Africa, North India and a few other countries being sufficient to supply the world's market with the whole quantity required. But within the last decade this condition of things has altogether changed. On the one hand there has been a constantly and rapidly increasing demand ; on the other, a supply which, if not constantly diminishing, has been more and more expensive to win, owing to the methods inevitable in jungle tapping which have led to the killing of the rubber-yielding trees over larger and larger areas. The result has been an increasing price for the rubber required by the trade, until in all climates and countries suitable for its culture, there is promise of its being one of the most profitable of tropical crops.

Among the hundred or more rubber-yielding plants of the world, however, there seem to be very few which yield a sufficient quantity of a rubber of good enough quality to pay for cultivation. At present it may be said that there are practically only four plants in commercial culture. These are the Para rubber of Brazil (*Hevea brasiliensis*), the Central American rubber (*Castilloa elastica*), the Assam rubber (*Ficus elastica*) and the Ceara rubber (*Manihot glaziovii*). Others may be and are in the experimental stage, and Ceara itself can hardly be said to have passed beyond the region of experiment. Under suitable conditions, there is no doubt of the superiority for commercial culture of the first two of those named, provided the conditions of their growth are found in perfection. They both require a warm equable climate. In addition, the Para rubber needs a continually moist soil, which never becomes dry to any depth, and an atmosphere which is generally or indeed

PLATE XXVI.

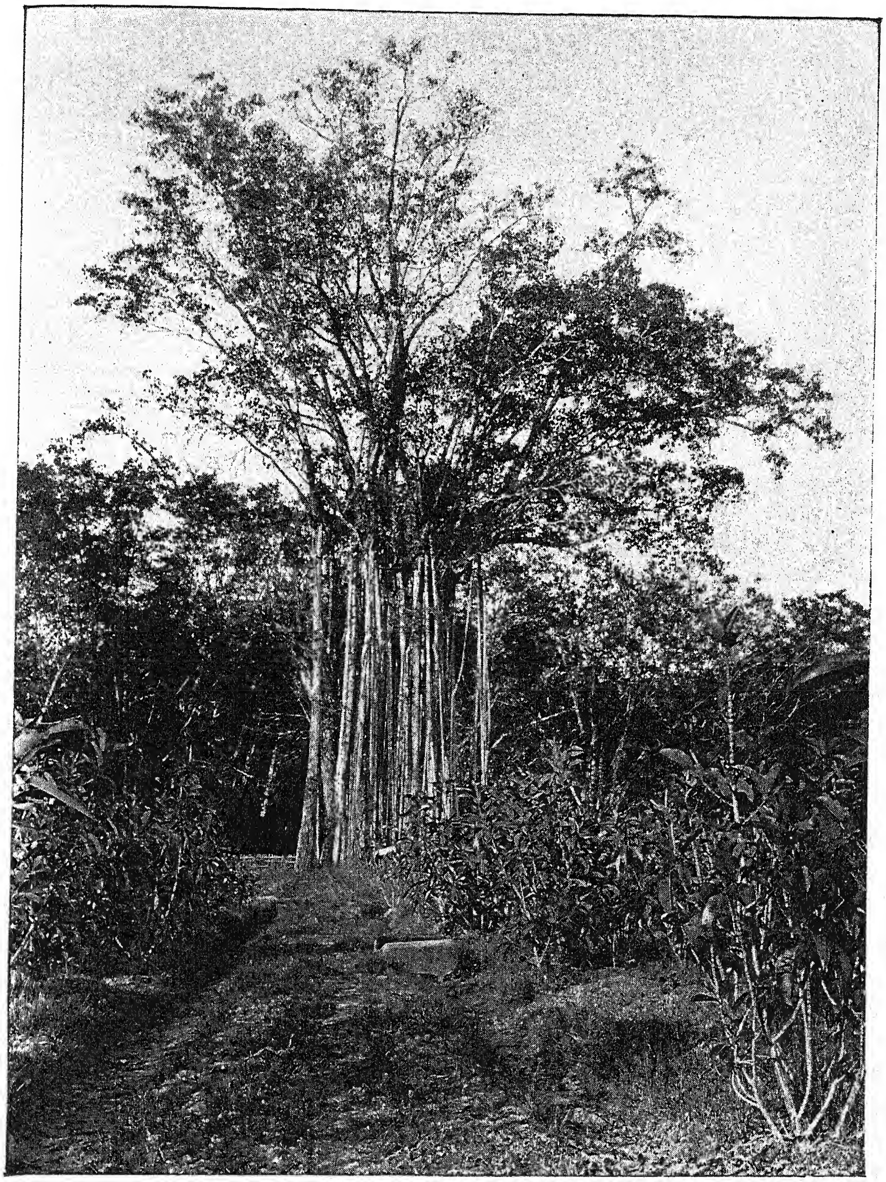


Photo. Mechl. Dept., Thomason College, Roorkee. E. M. Coventry, Photo.

NATURAL RUBBER TREE ABOUT 120 FEET HIGH.

This tree yielded 30 lbs. of rubber at one tapping.

(Reproduced from Forest Bulletin IV of 1906)

almost always moist. The Castilloa rubber does not seem to be quite so particular in respect of the presence of a continually moist atmosphere or soil, but is quite as rigorous in its demands in other directions. Another point deserving notice is that even if either of these or other rubber-yielding trees were capable of growing under unusual conditions, it by no means follows that they would then yield the same amount of rubber. On the other hand, it is most unlikely that this should be so. There is strong evidence that *Ficus elastica*, taken away from the steamy forests of North-East India or places of similar climate, hardly yields any of the commercial product, and I have been present at the tapping of a mature Ceara tree in Sylhet, when nothing but a trace of rubber was obtained.

This is unfortunate for North and North-East India. The best rubber trees (Para and Castilloa) will not grow there or will only grow with difficulty, and if they did grow, there is no security for their yielding a paying quantity of rubber ; so that if these districts had to depend on the introduction and acclimatisation of these trees, it is probable that they would never grow rubber at all. But there is a tree of which these parts of India is the natural home, and whose product originally gave the name of 'India-rubber' to the commercial article. This is the Assam rubber or *Ficus elastica.* This tree, however, possesses grave disadvantages over the others named. It grows more slowly : when grown, its habit makes it more difficult to work : very much fewer trees can be planted on the same area : the rubber it produces is inferior to that from Para or Castilloa trees. In spite of all these disadvantages, there seems a possibility of fair returns being obtained by its culture under suitable conditions, and such returns have already been obtained in Java, in the Malay States, and in a sense on the rubber plantations belonging to the Indian Forest Department in Assam.

The interest in the subject has called forth during the present year two pamphlets giving information for intending cultivators of this tree, and the present article may be considered as a review of these publications. The first of these ("The Cultivation of *Ficus elastica*" by Mr. C. Bald) is written by a Darjeeling tea planter, who has, for the last few years, been growing rubber on an experimental scale on the property of the Lebong tea company. He has gathered together a considerable number of facts, some of them new, and places them before the public in a lucid and practical fashion. With regard to the growth of young seedlings, the formation of '*gooties*' (or layers) and their use, the cultivation of the young plant, and like matters which have come within the author's personal experience, we could not wish a better guide. In respect to the method of tapping and the yield of trees,

where he is speaking obviously at second hand, his pamphlet is not so valuable.

The second publication (" *Ficus elastica* : its natural growth and artificial propagation," by E. M. Coventry, Deputy Conservator of Forests) is an official publication of the Forest Department of India, and contains a summary of the experiments made and the results obtained at the Government rubber plantations in Assam. It is hence unique. No one has had a fraction of the chance of observing everything in connection with the culture and tapping of *Ficus elastica* in North-East India that has fallen to the lot of the forest officers in charge of these plantations, and their conclusions are therefore invested with a weight and an authority which the writings of no other person in India can hope to have.

These plantations, as is very generally known, were commenced in 1873, and have been gradually extended from an original area of 180 acres to nearly three thousand acres. They lie at the foot of the Himalaya in the Darrang district and at the foot of the Khasia Hills in the Kamrup district of Assam. Tapping was commenced in 1898, and rubber has been produced for the market in every subsequent year. In any consideration of the results, it must be remembered that those in charge of these plantations have had to feel their way from the commencement : when they were started, little or nothing was known of the culture of Assam rubber : their whole career has been a history of experiment, much of which has proved absolutely futile, and hence the commercial results cannot be compared with those obtainable by others starting with their experience as a guide. It would also appear that the commercial element has not been allowed to enter into the management of these plantations sufficiently to make them an altogether safe guide for any one entering rubber culture with the question of profit solely in view. But, although this is the case, yet it is possible to obtain a large number of data from Mr. Coventry's bulletin, and a very valuable note appended to it by Mr. Eardley-Wilmot, Inspector-General of Forests, supplemented by the experience in growing young rubber plantations possessed by Mr. Bald. I do not intend here to discuss the details of Assam rubber culture,—these can be obtained from the pamphlets themselves,—but to indicate in some measure what appear to be, so far as one can tell, the commercial possibilities of growing *Ficus elastica*, based on the data supplied by our authors. The factors which will determine the practical success of Assam rubber may perhaps be set out as follows :—

(1) The initial or capital cost of forming a rubber plantation and bringing it into bearing.

(2) The age at which the trees will commence to yield.

(3) The yield which may be expected per tree and per acre.
(4) The cost of working a bearing plantation, collecting the rubber, and placing it on the market.
(5) The value per pound of the rubber produced.
(6) The permanency of the plantation.

The initial or capital cost of a rubber plantation cannot be judged, as Mr. Eardley-Wilmot justly remarks, from the experience on the Government plantation, seeing their essentially experimental character. The actual amount expended on them, however, appears to have been Rs. 72 per acre (Bald), and this takes no account of the rent of the land or interest on capital, both of which factors must of course be considered in any estimate of capital charges. Mr. Bald estimates this cost (again excluding rent, interest and expense of management) at Rs. 50 per acre. The only other figure of any value which has come to my notice is contained in a report of the Assam Valley Rubber Estates Co., Ld., where, when the oldest part of the plantation was seven years old, practically Rs. 40 per acre had been expended on the whole thousand acres then planted. But it is obvious that the actual cost will vary very much according to the conditions under which a plantation is put out. Considered as a bye-product to tea culture, the management and supervision would generally be paid, in the first instance, simply by a commission on each successfully planted area to a man already on the spot. If the concern is to run as a separate venture, naturally the cost of management is enormously increased, but a much larger area can be put out in a much shorter time. If we neglect this item for the moment, there remain to consider the rent, the cost of preparing the land, the expense of maintaining the plantation till it begins to yield, and the interest on the money expended during the waiting period.

In the tea districts of India waste land can generally be obtained for special culture on a thirty-year lease at an annual rent rising from nothing in the first three years to one rupee per acre in the last five years of the lease. No doubt many tea companies possess fee-simple land, and others waste land which they are compelled by circumstances to hold, but which they cannot use for tea. In these cases it is perhaps possible to ignore the item of rent, but in all others at least 8 annas per acre per annum must be put down on this account till the rubber comes into bearing. What this length of time will be, we will further discuss later. For the moment, let us place it at fourteen years, and hence the rent during this period at Rs. 7.

The cost of preparing the land is placed by Mr. Eardley-Wilmot at a maximum of Rs. 20 to Rs. 30 per acre, if forest land be used. The later part of the Tezpur plantings is said by Mr. Bald to have cost Rs. 35 per

acre up to date, or deducting Rs. 10 for plants, the cost of preparation and maintenance up to the present, would for this area be about Rs. 25. Mr. Bald himself places the cost of preparing the land, obtaining the plants, and tending the plantation till in bearing at eleven or twelve years old, at Rs. 50 per acre, which may perhaps be taken as a fair allowance under the most favourable conditions. If the time of yielding is delayed, naturally the cost will be greater, and at this stage the increased amount should not be placed at less than Rs. 3 per acre per annum, or a total of Rs. 56 per acre, if fourteen years be taken as the time to elapse before tapping is commenced. This low rate can only be hoped for, however, where the labour is already on the spot and available at any time.

This amount includes the necessary cost of the plants, which will vary nevertheless with the method of preparing them for planting. The approved method in Tezpur is to plant seedlings not less than ten feet high during the rainy reason. To obtain such plants, it is, according to Mr. Coventry, necessary to germinate the seed in beds till one to two inches high, plant into nursery beds where the plants stay for a year, transplant into stockaded nurseries in the forest for another year, and then put out into their final position. Mr. Bald does not consider that all this is needed, and puts out the rubber at five feet high into its final position. I am informed, however, that in the young gardens of the Jorehaut Tea Co., the big plants have done much better than the smaller ones, and this would indicate that the Tezpur method is the best. Most authorities agree that seedling plants so obtained ultimately produce the best trees, but recently a good many experiments have been made in planting out 'gooties' or cuttings rooted on the tree before removal of the branch. Mr. Bald apparently strongly advocates this method; Mr. Coventry speaks with considerable caution. There is no doubt that large rooted plants can be quickly obtained by this method, and apparently two years saved in the growth of a plantation, but it seems that such plants are liable to stand still for a very long time before commencing vigorous growth. They are also said not to produce aerial roots, but this is quite disproved by Mr. Bald. There is furthermore a tradition that the amount of rubber yielded by such plants is always very small, but I have sought in vain for any reliable evidence of such being the case. On the whole, it may be said that at present it seems risky to trust to 'gooties', and it is quite possible that the two years apparently so saved may not be a real gain at all. The matter, however, remains extremely doubtful.

If seedlings be used and planted 16 to 20 to the acre, Mr. Eardley Wilmot places the cost of plants ten feet high at Rs. 20 per acre—undoubtedly

PLATE XXVII.

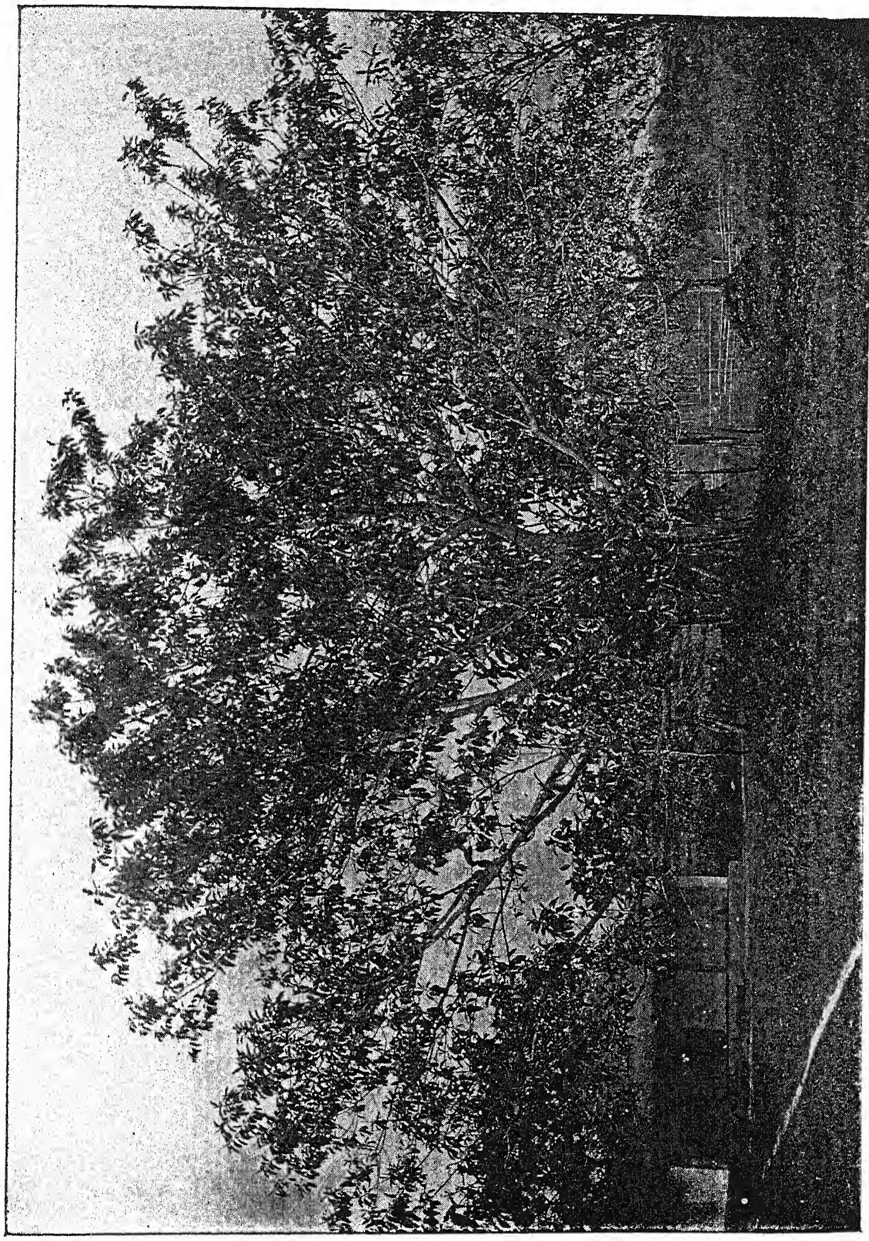


Photo.- Mechl. Dept., Thomason College, Roorkee.

E. M. Coventry, Photo.

PLANTATION TREE, 55 FEET HIGH, ABOUT 15 YEARS OLD.
(Reproduced from Forest Bulletin IV of 1906.)

a very high estimate. There seems too almost a consensus of opinion that more plants than this should be put in an acre. Mr. Bald recommends 35 feet apart triangularly, or 41 plants to the acre. Mr. Eardley-Wilmot is inclined towards closer planting than has been customary at Tezpur, and one new plantation at least has tried where the plants are only 20 feet apart. The whole question is very uncertain, for the Tezpur experience, and this alone, has rather told in favour of wide planting. There it has been stated that the yield was proportional to the lateral spread of a tree, but the evidence for this statement is very unsatisfactory. In any case Rs. 20 per acre ought to be sufficient to cover the cost of plants.

The expense of maintaining a plantation till it reaches a yielding stage might possibly be reduced, as suggested by Mr. Bald, by growing catch crops on the land, but whether this is possible or not, there is no present evidence to show.

Thus planted out in the fashion approved by our authors, and excluding cost, management and supervision, the expenses of bringing a plantation into bearing would be approximately as follows :—

Rent of land under 30 years' lease for fourteen years	Rs.	7
Cost of preparing, planting and maintaining till in bearing (14 years), labour being always available	,,	56
Cost of plants	,,	20
Interest on Rs. 83 for say ten years at 6%	,,	50

Thus we have a total of Rs. 133, without considering the cost of management and direction at all. It is evident, therefore, that Mr. Bald's estimate of Rs. 150 in all is not above the mark, but probably considerably below it, unless such a rubber plantation can be run in connection with an existing tea or other estate.

It will be seen, however, that the whole of the above argument is affected in the most serious manner by the doubt as to the length of time required to bring the plantation into bearing. We have calculated on fourteen years, but the Government plantations were only tapped at twenty-five years old. If this delay be a necessity in North-East India, it places the culture we are discussing out of court as a practical question except in special cases. But fourteen years appears to be the normal time in Java. Mr. Bald, on evidence which he does not quote, expects a yield in eleven to twelve years, but does not expect full yields till the trees are fifty years old. Mr. Eardley-Wilmot thinks that by planting more closely a yield could be obtained at 12 to 14 years. Most of these figures are guesses so far as North-East India is concerned, and certainly any calculation should not be based on an earlier yield than fourteen years.

"The yield of the Assam plantations," says Mr. Eardley-Wilmot, "is extremely small; we read that in Java on a plantation of 72 acres, on which were planted 5,200 trees, tapping commenced at 14 years of age, and that after 7 years' work the outturn per acre per annum was 71 lbs. of rubber. At Charduar the outturn of 23 to 25 years old trees is about one-sixth of this amount, and this justifies further enquiry as to the method and recurrence of tapping operations." This statement contains absolutely all that there is to say about the known yield of cultivated *Ficus elastica* in North-East India. At Charduar, it is found that tapping can only be done every third year, and each time only two pounds of rubber per tree are obtained on the average. The largest yield per tree last year was 7 lbs. 15 ozs. The yield, too, does not seem to be increasing in successive tappings of the same area (after the first). An estimate was made many years ago that 10 lbs. of rubber should be obtained from every mature tree in every second year, but nothing like this has been or seems likely to be obtained in the Assam plantations. If it were, as Mr. Bald remarks, the yield of a plantation, planted as he recommends, it would be 205 lbs. of rubber per acre in alternate years—an amount as yet never approached in India.

The question of yield, most vital as it is, seems to be the most doubtful in connection with the Assam rubber plant. A thorough, careful, close investigation is emphatically needed as to the best methods of tapping and the resulting yields. The present tools used, though a great advance on the older method of cutting with a *dao*, are clumsy and unsatisfactory indeed. The method of allowing the rubber to congeal on the cuts is also very unsatisfactory. The best time of year for tapping seems quite undetermined, both as regards yield and quality of rubber. In view of the very great improvements in tapping other rubber trees in the last five years, and the extremely crude character of the V-shaped gouge used at Tezpur, we cannot consider the figures for yield to have any finality whatever. This is felt by Mr. Eardley-Wilmot when he says "It is possible that the vitality of the tree suffers from the removal of such a large percentage (about 4 per cent.) of its bark during each tapping operation, and that this, and not so much the flow of latex, renders yearly tapping impossible. This is a subject on which more knowledge is required." The method now in use for cutting the trees is shown in Plate XXVIII.

Altogether we may say that if the present Tezpur yield only is obtained, the culture of *Ficus elastica* is not and cannot be made a commercial success: there are strong grounds, however, for believing, in view of results in Java and the Malay States, that with an improved system of tapping much larger yields can be obtained, even three or four times the present amount.

PLATE XXVIII.

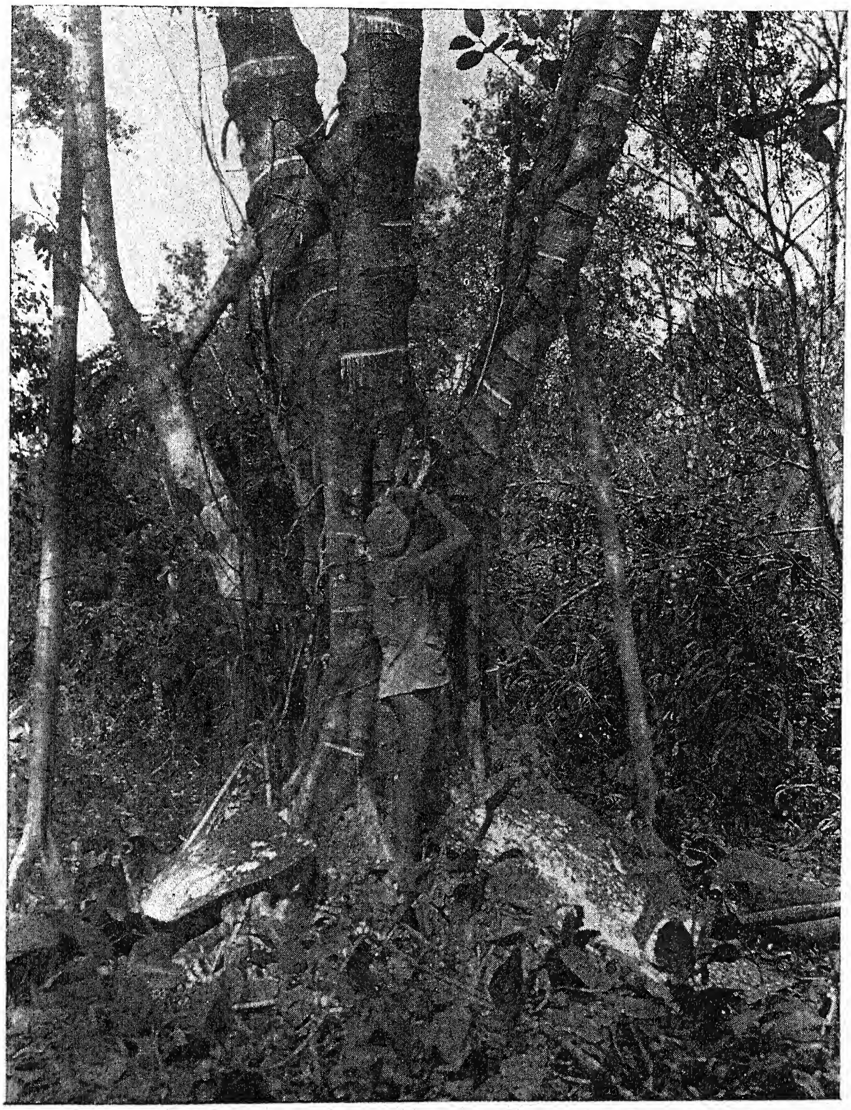


Photo.- Mechl. Dept., Thomason College, Roorkee. E. M. Coventry, Photo.

METHOD OF TAPPING.
(Reproduced from Forest Bulletin IV of 1906.)

The cost of maintaining the Tezpur plantation, collecting the rubber, and placing it on the steamer at Tezpur, amounted to 6 annas 10 pies per pound of clean rubber in 1904-05. This, of course, allows nothing for management or rent. The cost per acre of bearing rubber—as 30lbs. per acre tapped once in three years were being obtained—would hence be Rs. 4-4-4 per annum. In that year Rs. 2-11 per pound was obtained or Rs. 26-14 per bearing acre, the nett return being therefore Rs. 22-9-8 for this area. This is, of course, a very minute profit when the cost of management and the rent are subtracted. Judging from Mr. Bald's estimate, it is not likely, however, that the cost of winning here set out is likely to be decreased materially.

We have now to consider the value, present and prospective, of the rubber produced from the *Ficus elastica*. It is well known that it has never approached the value of the best Para, and according to the most reliable information it is not likely to do so for the simple reason that it is not nearly so pure. The best Assam rubber contains from 3 to 7 per cent of resin : the Charduar plantation produce has hitherto contained considerably more. It has generally been supposed that this resin is naturally present, and hence cannot be reduced by any change in method of manipulation, which is probably the case. Young trees, too, are very apt to give a rubber containing more resin than old ones, and of course all the plantation trees are young ones. On the market Assam rubber always obtains a lower price than Para, generally about from sixpence to one shilling per pound less. Being an inferior article, it must be remembered that supposing in the future the supply overtakes the demand, the poorer rubber will be the first to suffer. This danger at present appears somewhat remote, but cannot be ignored in dealing with a product which will only come into bearing at the earliest in twelve to fourteen years.

Only one point remains. What is the probable age to which a plantation regularly tapped will last? It is well known that the tapping methods hitherto in use in the jungle have killed out almost every rubber tree in the Assam Valley, in Sikkim, and in most of the lower hills surrounding North East India. It has also been found at Tezpur that annual tapping of the same tree causes a rapid decrease in the amount of rubber obtained. Thus fifty trees were tapped each year between 1898 and 1901, and the yields were respectively 55½ lbs., 42¼ lbs. and 14½ lbs., or a reduction of nearly 75 per cent. in the third year. In another case the old cuts were re-opened, and fifty trees then gave, in three successive years, 43 lbs., 35¾ lbs. and 24 lbs. respectively, or a reduction of nearly 45 per cent. In fact, at Tezpur it has been found necessary to tap the trees only in every third year, if the yield is to be maintained. How far this is due to the

method of tapping, and how far it represents what would always be the case with this tree are, at present, quite unknown, though they are vital questions to any possible industry. So far as we know it may be said, therefore, that annual tapping quickly ruins the trees; that tapping every second year may or may not be possible; and that tapping every third year may be carried out without danger to a plantation.

What then is the result of our discussion, on the basis of the data supplied by Messrs. Coventry and Bald, into the commercial possibilities of Assam rubber culture in North-East India? The first feeling on rising from a perusal of the pamphlets is one of disappointment. The prospects are so doubtful, and even if successful, so poor as compared with the culture of Para or Castilloa rubber in Ceylon, the Malay States, or even South India, that one is inclined to consider any large extension of the culture of *Ficus elastica* in North-East India as out of the question. And I must say that this impression has been very strongly confirmed by almost all that I have seen in these districts, if the Assam rubber is to be cultivated as a separate industry. On present evidence the length of time which it is necessary to wait for returns, the smallness of the returns when they are obtained, the doubt as to the market fifteen to twenty years hence would seem to make investment in Assam rubber culture, as a separate venture, a very doubtful speculation in North-East India at any rate. I do not see how, at the rate of outturn obtained now at Tezpur, more than Rs. 15 to Rs. 18 per acre profit could be obtained per annum; and even if this were multiplied by 4, it would hardly be attractive enough to induce an investor to wait over twenty years for the result. In fact, the only possibility of *Ficus elastica* culture would seem to be as a bye-product to tea culture, on land now waste and unsuitable for tea. In this case, the growth of Assam rubber may afford a means of turning land to profitable account which could otherwise only remain useless to its owners. It may be that future discoveries with regard to improved methods of tapping, new methods of growth, means of tapping the plants annually without injury, or of growing a larger number of healthy heavily-yielding plants on the same area, may alter the opinion above expressed. But as it stands, and with the data before us in the two pamphlets under review, I feel that no other conclusion is possible than that Assam rubber culture can only continue as a dependent of another larger and more profitable industry, and then can only occupy the inferior land.

NOTE.—The plates illustrating this article are reproduced, with the permission of the Inspector-General of Forests, from Forest Bulletin No. 4 of 1906.

NOTES.

The Production of Wheat in India.—The final memorandum on the Indian wheat crop of 1906, issued by the Director of Commercial Intelligence, states that this year's crop of 8,560,000 tons is the second highest on record and falls short of only one recorded year, 1904, when 9,641,000 tons were produced. It will be seen from the following table that nearly 75 per cent. of the wheat grown in India comes from the Punjab (including the North-West Frontier Province) and the United Provinces of Agra and Oudh.

Province.	Yield (in tons).	
	1906 crop.	Average of preceding 10 years.
Punjab	3,510,300	2,034,900
United Provinces	2,428,700	2,283,800
C. P. and Berar	827,800	499,800
Central India	418,000	294,300
Bengal	400,000	420,400
North West Frontier Province ...	279,700	220,600
Bombay (including Native States) ...	270,700	450,300
Sind (including Native States) ...	193,100	124,000
Rajputana	141,500	238,800
Eastern Bengal	50,000	71,400
Hyderabad	40,400	44,400
Mysore	140	380
Total ...	8,560,340	6,683,080

In the Punjab the outturn has been half a million tons higher than the previous record crop of 1904.

The extent to which the 1906 crop was irrigated in the three chief wheat-growing provinces is shown in the next table—

Province.	Area (in acres).			Percentage of area irrigated.
	Irrigated.	Unirrigated.	Total.	
Punjab ...	4,615,400	3,956,700	8,572,100	54
United Provinces ...	3,668,453	2,699,040	6,367,493	58
C. P. and Berar ...	18,738	3,003,440	3,022,178	0·62

Although the extension of canal irrigation in Northern India will no doubt increase the percentage of irrigated wheat and tend to secure the wheat crop as far as internal consumption is concerned, nevertheless it is extremely probable that the export of Indian wheat will continue to depend largely on the distribution and amount of rainfall at sowing time and during the growth of the crop.

The exports of Indian wheat to foreign countries by sea during the last five years are now given, the figures for the crop of the present year being not yet available—

Year.	Export (in tons).
1901-02	366,091
1902-03	514,607
1903-04	1,295,566
1904-05	2,150,025
1905-06	937,523

The importance of India as a source of supply of wheat for European consumption has only been recognised in very recent years. Thus Sir William Crookes in *The Wheat Problem* (published in 1899) does not include India in his table of the contributory areas of the world's wheat crop of 1897-98, but makes the following reference thereto in a footnote to the table in question :—"Outside the better known areas of wheat supply, a certain proportion of wheat comes from India, Persia, Syria Australia and North Africa. But it is impossible to get accurate figures as to acreage and yield from these countries ; as bread eaters derive less than one per cent. of their supplies from these outlying sources, it is convenient to call the ordinary areas 'contributory areas,' and to deal with the external areas no further than to show the volume of imports yielded from year to year."

That the prophet is always at the mercy of events is well illustrated by comparing the following reference to India in this work and the figures given in the table below :—"The enormous acreage devoted to wheat in India has been declining for some years, and in 1895 over 20,000,000 acres yielded 1,85,000,000 bushels. Seven-eighths of this harvest is required for native consumption, and only one-eighth on an average is available for export."

AREA AND YIELD OF WHEAT IN INDIA.

Area (in acres).		Yield (in bushels).	
1906 crop.	Average of preceding 10 years.	1906 crop.	Average of preceding 10 years.
26,226,200	24,174,500	319,288,000	249,278,884

It is clear that the figures of 1895 quoted by Sir William Crookes for area and yield have been largely exceeded in subsequent years, and with the extension of canal irrigation in the North-West are likely to be still further exceeded in the future. Moreover, in the record year of 1904-05 the wheat exported from India by sea amounted to 80,200,000 bushels, while the average export of the last five years has been 40,000,000 bushels, nearly twice that indicated as the maximum possible export by Sir William Crookes. The author of *The Wheat Problem* has omitted to consider the importance of India as a source of supply of wheat for European consumption. Instead of the minor position accorded to India in this respect by Sir William Crookes, it is evident that India already takes a high place in the world's wheat-producing areas. Coming to the well-known remedy suggested by Sir William Crookes for averting the wheat famine we are to expect during the present century and for increasing the production of the wheat-growing area, namely, the use of artificial nitrate of soda as a manure for wheat, it is difficult to see how this panacea can be made use of by the Indian cultivator. Even if the ryot could afford to buy this manure, it is doubtful whether it should be applied to Indian soils in view of its deleterious effect on the physical condition of the soil and to the uncertainty of any increase in crop in a country where the distribution of the rainfall cannot be relied upon and where sodium salts are even now apt to accumulate in the surface soil to a dangerous extent. The Indian cultivator has little to learn regarding the value of leguminous crops on wheat lands and the necessity of good cultivation for wheat. We must look, therefore, in other directions to find some means of improving the wheat cultivation of India. The direction in which the greatest amount of good can be done at present is undoubtedly the protection of existing wheat areas in periods of drought by canal and well irrigation, and by the construction of new canals in the desert regions of the Punjab and Sind. Already considerable progress has been made in this direction, and large schemes for future work have been sanctioned. In addition to this, the question of the improvement of existing varieties of wheat is receiving considerable attention, especially in the United Provinces, and it is hoped that valuable results will follow from these investigations.—(A. Howard.)

*
* *

THE MIXTURE OF WHEAT VARIETIES IN INDIA.—The wheat fields of India usually contain more than one variety of wheat. In some cases, as many as twelve different sorts can be found even on a cursory examination of the ripe standing crop. The samples of threshed wheat in the markets and mills are also mixed, as well as those sold to merchants for export to

Europe. This admixture is doubtless largely due to the methods of threshing and storage and to the fact that much of the seed for the next crop is bought in the market from the grain dealer and not saved by the cultivators themselves.

In the drier districts of the Punjab, it is possible that other causes may be at work, which would partly account for the admixture of types. During harvest time vast numbers of ants are to be seen busily carrying wheat grains into the ground, and it is possible that some of these grains may be brought to the surface when the land is cultivated for the next rabi crop and give rise to new plants. Some wheat also remains on the ground after reaping, which, in view of the small summer rainfall, may escape germination and form part of the next wheat crop. As an example of the small amount of summer precipitation in these regions, the rainfall of Lyallpur from May to October for the years 1899 to 1903 may be quoted :—

	Inches.
May	·55
June	1·10
July	2·65
August	1·18
September	2·2
October	·17

This question of the mixing of varieties is of considerable importance in experimental work and on farms where wheat is grown for purposes of seed distribution. Field experiments with wheat, such as manurial, cultivation, and variety testing experiments, should obviously be carried out with the varieties pure. If this precaution is not observed, errors are bound to creep in through one of the varieties getting the upper hand and thus altering the proportions of the mixture. In seed distribution it is clear that one of the principal objects of the work will be lost unless pure types are given to the cultivators. In all these cases not only must pure seed be sown, but also the land in which the wheat is planted must be free from foreign seed. In most parts of India except the Punjab and Sind, the wheat grains from previous crops are almost bound to germinate and to be destroyed in the summer unless there is almost a total failure of the rains. In the drier regions, however, it would appear possible for wheat to be carried over from the previous crop. It would be interesting to see whether this is a real danger or not. The point could easily be settled by leaving portions of wheat land in these tracts uncultivated during the summer till the next sowing period when they could be ploughed up, irrigated and left unsown so as to determine whether any wheats appear.

It is simple to free a variety of wheat from other types when the plants are ripe at harvest time. The foreign sorts can then be detected with great ease and can be gathered by hand and separated before the plot is reaped. It is more difficult to do this after the wheat is cut, and quite impossible to do so when the grain is threshed. It is true that red and white, hard and soft, grain can be picked out of a mixture, but several distinct varieties may give rise to grains which appear to the eye identical. As illustrating this point, it may be mentioned that a sample of wheat which to the eye appeared fairly uniform was sown in the autumn of 1905 and gave rise the following spring to no less than thirteen distinct varieties.

The storage of a large number of wheat varieties is a matter of some difficulty in experimental work, as it is so easy to get the varieties mixed. The only satisfactory method seems to be to keep the ears and thresh them out just before sowing. The bulk of the material is a disadvantage, but this is a small matter in comparison with the certainty of keeping the experimental wheats perfectly pure. Where wheats are exchanged for trial from one experimental farm to another, it would be an advantage to send the varieties in ear and not as seed.—(A. Howard.)

*
* *

WEEDS IN PUNJAB WHEAT FIELDS.—The importance of leguminous plants in wheat-growing has been recognised in practice from the earliest times. It was known that the growth of these plants in some way enriched the soil for the subsequent wheat crop, but it was not till late in the last century that a scientific explanation of the part played by the leguminous crop was forthcoming. It was then recognised that the bacteria in the root-nodules of these plants are able to make use of atmospheric nitrogen for the leguminous crop and also to leave a considerable store of nitrogenous manure for the succeeding crop.

The Indian ryot has not been behind Western practice in this respect. In all the important wheat-growing districts of India, except the irrigated districts of the Punjab, we find that the practice of growing leguminous crops on wheat lands is universal. In the United Provinces "the commonest rotation of all is for wheat to follow a Kharif crop of the preceding year, *juar*, *bajri* or cotton mixed in most cases with *arhar* or a creeping pulse, e.g., *urd* (*Phaseolus radiatus*) or with both of these. After wheat it is almost universal to take a mixed Kharif crop containing *arhar* or a creeping pulse or both." (Moreland).* In the Central Provinces, "in *kanhar* and *kabar* soils wheat and gram as a mixture are grown year after year

* Proceedings of the Board of Agriculture in India, 1906.

which serves the purpose of a rotation. In *morund* and certain other classes of soils, Kharif and Rabi crops are rotated in places where wheat can be grown. Generally, when they have a rotation, wheat is grown after gram, masur (*Ervum lens*) or teora (*Lathyrus sativus*) (Gaskin).* In Bengal "wheat is generally sown mixed with gram and a little linseed. After two or three years a crop of peas is taken."—(D. N. Mookerji).*

On the other hand, in the important irrigated wheat districts of the Punjab, we find that wheat is grown on the same land year after year apparently without any great diminution in the fertility of the soil. The wheat-gram mixture has not proved a success on these lands, as the two plants differ in their water requirements. How then is the fertility of these soils kept up under successive wheat crops and without the use of manure or the fertilising effects of leguminous crops? That nitrogenous manures are not needed is seen by the dark green colour of the leaves and the general vegetative vigour of the wheat crops. That the land was not virgin soil in the ordinary meaning of the term is clear when we remember that these lands were desert wastes with little vegetation and therefore small accumulations of organic matter. Whence do the large wheat crops derive their nitrogenous manure? Apparently the answer is to be found in the leguminous weeds which thrive so luxuriantly as a bottom growth in the wheat fields of the Punjab.

There are three common leguminous weeds in the Punjab wheat fields—(1) yellow flowered *senjhi* (*Melilotus indica*), (2) white flowered *senjhi* (*Melilotus alba*), and (3) a creeping clover-like plant with curious curved pods (*Medicago denticulata*). These three plants also grow and seed freely on the banks of the water channels, and are very probably distributed by the irrigation water. In the wheat fields they ripen their seeds and dry up by the early part of April before the wheat is cut and thus give no trouble at harvest time. At flowering time in March, their roots are covered with nodules. Their general vigour shows that they are admirably adapted for bottom growth with wheat.

It would appear, therefore, that these weeds confer on the soil of the irrigated wheat lands of the Punjab all the benefits of a leguminous rotation, and supply the nitrogenous manure required by the wheat crop. In this respect, the wheat-growers of the Punjab seem to be specially favoured by circumstances, as they are able to obtain all the benefits of leguminous crops without any trouble or expense and without the diminution of wheat output entailed in the usual rotations practised on wheat lands in other

* Proceedings of the Board of Agriculture in India, 19

parts of India. No difficulty would be experienced in obtaining seeds of these leguminous plants. They grow and seed freely among the wheat in waste places and on the banks of the water channels. Yellow flowered *senjhi* mixed with the other two weeds is grown as a cold weather fodder crop in the Punjab and sometimes left to ripen for seed purposes.

Experimental evidence regarding the fertilising value of these plants would be of the greatest interest. The produce of land under wheat alone compared with that of an equal area under wheat mixed with these leguminous weeds could not fail to be of value. The difference in yield may not be great for a few years, but after a time it is likely that the influence of the leguminous crop in increasing the fertility of the soil would be apparent. The experiment would present some difficulty, as it would not be easy to get rid of the *senjhi* seeds in the ground in the first instance, and the irrigation water for the *senjhi*-free plot would have to be filtered, so as to remove floating seeds.

The weeds growing on the banks of the water channels in the irrigated districts of the Punjab are not all useful. Several are distinctly harmful, and their seeds are freely distributed with the irrigation water over the wheat land, when they thrive vigorously. The two commonest of these weeds are (1) *Chenopodium album*, a tall annual weed, dark-green at harvest time and standing out in strong contrast with the ripe wheat crop, and (2) *Asphodelus fistulosus*, a dwarf plant with a tuft of onion-like leaves belonging to the lily family. It is probable that if steps were taken to keep the banks of the water channels free from these weeds, their number would be considerably diminished. Badly infected land might easily be cleared during the summer by irrigation, so as to cause the seeds to germinate, and by subsequent cultivation to destroy the resulting seedlings. In addition to the destruction of weeds this cultivation would no doubt benefit the soil. A similar principle is adopted in England to clean foul stubbles in early autumn.—(A. Howard).

*
* *

IRRIGATION WELLS IN THE UNITED PROVINCES.—The recent drought in the Southern districts of the United Provinces gives renewed interest to this subject; in many cases the wells failed wholly or partially during last hot weather, and the supply was insufficient even for domestic purposes, leaving irrigation out of account. It is now an established fact that *in the alluvium* the supply in spring wells can be increased in very many cases by the simple and rapid process of putting a bore through the bottom of the well down to the next lower spring. To give one case out of many on

record, in the Ghazipur district a well that was formerly exhausted in three hours by one pair of cattle was bored to an additional depth of 44 feet, at a cost of Rs. 37, and can now be worked continuously all day by two pairs of bullocks, thus increasing the supply at least eightfold for a nominal expenditure.

Operations of this nature have been carried out systematically and with success by Mr. T. Martin, a planter of Khorason in the Azamgarh District; to facilitate his work, he invented a special tool, now known as Martin's patent sludger, which, after exhaustive trials, has been adopted by the United Provinces Agricultural Department as the standard tool, both for boring in existing wells and for locating sites where wells can safely be built; with its aid, and a man trained to work it, few landholders in the spring-well tract of the alluvium need fear a water-famine under any conditions that are likely to arise.

It is greatly to be wished that some equally simple means could be devised of increasing the supply of water in wells sunk to the rock, where the risk of a water-famine is so often present. This subject has been studied in much detail by Mr. E. Molony of the Indian Civil Service, and the conclusion appears inevitable that in this case there is no royal road to success as there is in the alluvium. The most hopeful method is to bore a hole several feet deep at the bottom of the well and explode a heavy charge of dynamite in the bore. This measure shatters the rock round about the bore, and thus brings it into connection with adjoining cracks and fissures; but whether those cracks and fissures contain enough water to make the operation a success can be determined only by the result, and if an increased flow is not obtained at the first attempt, there is nothing for it, but to bore deeper and repeat the process until either a sufficient supply is obtained or the well is given up as hopeless.

Much information on this and on other subjects connected with wells will be found in the *Manual of Irrigation Wells*, which has been prepared by Mr. Molony, and will shortly be published by the Government Press at Allahabad.—(W. H. Moreland.)

*
* *

AGRICULTURAL DEMONSTRATION IN BOMBAY.—Special arrangements have been made by the Bombay Department of Agriculture to demonstrate to cultivators in the Nira canal tract some of the successful results of experiment work at the Manjri (Poona) Agricultural Station. These demonstrations, which will be conducted by an overseer of the department, will be mainly limited to the use of oilcakes as manures for sugarcane cultivation and to the cultivation of finer herbaceous

varieties of cotton under irrigation, in both of which matters successful results on an experimental scale have been secured at the Manjri farm. The overseer will distribute free of charge, and show the method of applying, oilcake manures in the sugarcane fields of selected cultivators ; he will also cultivate irrigated cotton on land rented from cultivators, so as to demonstrate the necessity for the avoidance of over-irrigation, which is very injurious to the crop. A considerable expansion of this class of demonstration work, which is necessary in order to introduce successful experimental results into general agricultural practice, may be anticipated in the future, with the increasing number of agricultural stations and the more careful supervision of their experimental work.—(F. G. Sly.)

*
* *

THE INTRODUCTION OF THE PERSIMMON FRUIT TREE INTO NORTHERN INDIA.—This fruit tree was first introduced into the Saharanpur Gardens in 1889, in which year a consignment of young plants was received from Florida. A further consignment, consisting of eighteen plants, was received from Japan in 1890, which was distributed between the above gardens and those of Lucknow and Lahore. A third importation was made in 1891, when twenty plants were received from Japan and planted out at Saharanpur, Simla and Mussoorie. In the following year thirteen plants were received by the Lucknow Gardens, and the last importation, consisting of thirty plants, was received at Saharanpur in 1899.

The earliest record of fruit is at Saharanpur in 1894, when one tree yielded a slight crop ; but it was not till 1898 that the trees generally came into bearing. Since that date, with seasonal fluctuations in quantity, they have fruited regularly.

This plant is a conical shrub some 10 feet in height, and shows a partiality for moderately light and sandy soil. The deciduous leaves fall in November, while the pendent fruit remains hanging on the bare tree till December. These, being a bright red, are very conspicuous and are eagerly preyed upon by bats and flying-foxes. It is, therefore, necessary to cover the tree with a net in November and December. The fruit ripens in December and early in January, and in appearance is most nearly comparable to a large conical tomato, but in consistency the flesh is soft and uniform and of a very delicate flavour.

Propagation is, in Japan, commonly effected by means of grafts. As, however, the plants which originally fruited in Saharanpur were all of seedless varieties, some other means of propagation or some other stock on which to graft had to be found. All efforts to propagate by layers and cuttings proved ineffectual, and attempts at grafting on seedlings of the

Indian species of *Diospyros* failed. In 1899 seed was imported from Japan, but the plants grew very slowly, and it was some years before the seedlings were sufficiently large to be grafted upon ; though the graft takes readily, this slow growth of seedlings is a severe impediment to their successful adoption as a stock. In 1903 seed of the *Amlokh*, a deciduous species of *Diospyros*, was obtained from Kashmir. These seedlings have thriven well and grown rapidly, and the persimmon can be grafted upon them with ease.—(H. M. Leake).

*
* *

STRAWBERRIES AT SHILLONG.—Twenty varieties of strawberry have been under trial at the Government Fruit Garden at Shillong, of which one was obtained in 1902 from the Saharanpur Botanical Garden, whilst the rest were imported in 1903 and 1904 from Messrs. Thomas Rivers & Son of Sawbridgeworth, Herts, and Messrs. Cannel & Co. of Kent, England. The variety obtained from Saharanpur, which grows more freely than any other, has been cultivated for many years in European gardens at Shillong, but always with a very disappointing result. The flowers appear in considerable numbers, but very few eventually set fruit. The berries are borne singly on long slender stalks, in this respect being unlike the newly imported varieties in which a single stalk may bear half a dozen or more fruits. Among the new varieties, four, *viz.*, Louise Gautier, Aprikose, Givoz Late Prolific and Sir John Paxton, have succeeded well. Louise Gautier seems the most prolific ; its berries are almost white when unripe, assuming a faint reddish colour as they ripen, irregular in shape, and rather watery in taste. This variety is decidedly inferior in flavour to the other three, though in point of productiveness it easily comes first. Aprikose is a large scarlet fruit with a most attractive appearance. Givoz Late Prolific and Sir John Paxton bear fruits of medium size, of a deep scarlet colour when fully ripe, and of the usual conical shape. The plots under experiment being very small, no record has been kept of the actual yield of fruit obtained from each variety, but these four English varieties promise to be quite successful. The cultivation of the Saharanpur strawberry, the kind which has been known at Shillong for many years, was attended with so much disappointment that few people cared to grow strawberries at all. Now that some good varieties have been introduced, it is hoped that this favourite European fruit will become popular among the gardeners of the station. Whether it will pay people to grow this fruit for the local market is not yet certain. Strawberry cultivation will always be a more or less speculative business in the climate of Shillong. A spell of wet weather in May, when the berries are ripening on the plants, may destroy a considerable proportion of the crop. Moreover, strawberry has a serious enemy in a

small ant which eats and burrows into the ripe fruits and for which no effective remedy has yet been found.—(B. C. Basu.)

*
* *

THE WOBURN FRUIT EXPERIMENTS.—*Annual Reports of the Woburn Experimental Fruit Farm, 1897 to 1905, by the Duke of Bedford, K.G., and Spencer U. Pickering, F.R.S. Eyre and Spottiswoode, London.*—It is now ten years since the experimental station for the study of fruit culture was started by the Duke of Bedford and Professor Pickering at Woburn. During this period five reports have been published, the last of which appeared in 1905. Just as the Rothamsted experiments have proved of the greatest value and interest to both practical agriculturists and to scientific investigators engaged in experiment station work, so it is not too much to say that the Woburn fruit experiments will prove equally important to fruit growers and at the same time of great scientific interest.

These experiments are very exhaustive, dealing with a large number of questions relating to the growth and management of fruit trees. They include permanent experiments on several varieties of dwarf and standard apples, on many kinds of strawberries, and on bush fruits, such as gooseberries, currants and raspberries, the growth of numerous varieties of apples, pears and plums on different stocks, and demonstration plots. A detailed account of the experiments would extend over many pages, and the reader interested in this subject should consult the reports themselves which are interesting, not only as a record of careful work, but as an example of the manner in which the results of permanent field experiments should be presented to the public. The first portion of each report is intended more for the scientific reader, and deals with the details of the various experiments with illustrations where necessary, while the latter portion consists of a summary of the results from the practical standpoint. In this way, the reports can be read with profit by experiment station workers and also by fruit growers who have neither the time nor the means to deal with detailed experimental work.

Some of the more remarkable and interesting results obtained at Woburn may be mentioned. The authors are careful to point out that these results are not necessarily of universal application, but are liable to considerable modifications under other conditions of soil and climate, and where other varieties are concerned. First in importance is undoubtedly the negative result obtained with manures. Neither as regards vegetative growth nor fruit production did the various artificial and natural manures applied have any effect. Of hardly less interest is the harmful effect of grass on the growth and bearing power of young apples, pears and plums. The trees in the plots grassed down were found to be profoundly affected in

all respects—they came into leaf earlier than the normal plots; their leaves turned an unhealthy yellow and fell prematurely; the trees remained in a dwarfed and stunted condition; the fruit borne on these trees was of small size and so differently coloured from the normal that judges of apples were unable to name them. These results were quite unexpected in view of the fact that many of the best of the older fruit orchards in England are under grass. Whether these results at Woburn apply only to *young* trees, and whether the plots at present under grass will recover, are questions that will be discussed in future reports. The most interesting of the results obtained with different methods of planting are those in which trees were planted without any special care. It was found that the trees recovered from the ill-effects in a few years, and in some cases did even better than those planted in the usual manner. This result was found to be due to the development, in some cases, of an entirely new root system. Enough has been said to show that the results obtained at Woburn will well repay perusal by all interested in fruit growing.—(A. Howard.)

*
* *

Soil Moisture.—The movement of water in Indian soils has been the subject of experiments at different times, but very diverse opinions are still held even in regard to fundamental principles, such as the power of certain soils to absorb moisture from the subsoil water, the extent to which capillary action supplies moisture to the plant, the power of certain soils to retain moisture, and similar problems. Doubtless much of the difference of opinion is due to the very diverse soils which investigators have dealt with. In the case of the *doab* soils of the United Provinces, there seems a good deal of evidence to show that much of the moisture required to support a winter crop during the long dry season following the monsoon is supplied by the system under which the field is embanked, so as to retain all the water falling on it during the rainy season, the loss of water by evaporation being also checked by constant cultivation of the surface.

The results shown in the table below were obtained by Mr. Har Narain Batham, Teacher of Chemistry at the Cawnpore Agricultural School, in some investigations made at my suggestion to test simultaneously the amount of moisture in fields receiving different treatment.

Field No.	Treatment.	First six inches.	Second six inches.
I	Growing cotton, not embanked	3·7	5·1
II	Fallow, embanked so as to hold up all rain and surface kept tilled.	8·1	12·4
III	Not embanked, not cultivated	3·7	8·2

The estimation was made at the end of the rainy season about one month after any rain had fallen. Moreover, during this season there had been only 17 inches of rainfall as against the normal of 35 inches, so that it was particularly suitable to test the effects of embanking land. Further, a comparison of the effect of two fields sown with wheat, one carefully embanked so as to retain water falling on it, and one in which this had not been done, both fields being fallowed and cultivated during the rainy season, gave similar results in the estimation of moisture to those shown above. In the embanked field, there was sufficient moisture to give good germination and to support the crop for some time, whilst in the other field germination was extremely bad and irrigation had to be given at once.

The above facts tend to show that in these soils with a water level at 20 feet, capillary action is not apparently sufficient to replace water allowed to run off the surface, and that to a large extent it is the rainfall absorbed and retained by the soil from above and not the capillary rise from below, which so much assists in supplying the needs of the crop. In writing the above note, I do not wish to suggest that capillary action is of no value. It doubtless differs greatly in different soils, but I simply wish to record results which seem to indicate that the capacity of a soil to retain moisture and the power of a plant to descend and make the most of such water storage is a factor equally important if not more so than any capillary action.—(J. M. Hayman.)

*
* *

Soil Inoculation.—The results of experiments in soil inoculation by the Canadian Agricultural Department are given in the evidence of the Chief Chemist, Dominion Experimental Farms, before the Select Standing Committee on Agriculture and Colonization, 1905. Experiments were carried on for several years with cultures prepared in Germany and known as "Nitragin," which are reported in the Experimental Farm reports for 1897-98-99. While it was shown that in certain instances the cultures had distinctly favoured the growth of the legume, the results as a whole were conflicting. The cultures, moreover, were found to be particularly susceptible to light and heat ; and under the best conditions their vitality could only be guaranteed for about six weeks from the date of preparation. There was not sufficient evidence to recommend this preparation for general use until further investigation and more satisfactory results showed that it was of practical utility.

The new cultures prepared by Dr. Moore of the Bureau of Plant Industry, Department of Agriculture, Washington, have caused a considerable re-awakening of interest in the possibilities of soil inoculation. "It

is claimed for these cultures that by reason of special modifications in the method employed in their preparation, they are more potent and much less susceptible to unfavourable conditions than the German Nitragin." Pot experiments were carried out last year with cultures for red clover and alfalfa (lucerne), sterilized light sandy soil being used. The experiments gave no definite results, there being no general increase in the weight of the crop from the inoculated pots as compared with that from the uninoculated ones. It is possible that the sterilization of the soil introduced an element of uncertainty, and further experiments are being carried out on a larger scale. Meanwhile "from our own experience we cannot report very favourably."

Dealing with the question of the enrichment of the soil by the growth of legumes and the various means for securing a vigorous growth of the crop, the Chief Chemist expresses the opinion, based on the observed general, although not universal, presence of nodules on the roots of leguminous crops, (*a*) that the necessity for inoculation is not so great as was at one time thought, (*b*) that the existence of the legume nitrogen-fixing bacteria is by no means restricted to small or isolated areas, and (*c*) that failures in the past to obtain good clover crops are, in many cases, to be attributed rather to other circumstances, *e.g.*, lack of moisture, bad tilth and the like than to the absence of nitrogen-assimilating germs. Nevertheless, it is pointed out that excellent results have been obtained in some districts by inoculating soils which grow poor crops of legumes with soil from land which grows good crops. The directions for inoculating according to this method are :—Mix the soil containing the bacteria with a larger quantity of other soil ; the whole is then broadcasted over the area to be inoculated, which is at once thoroughly harrowed.

Attention is called to the fact that the bacteria in the cultures are of direct use only to leguminous plants, and that benefit to the soil and to other crops can solely be obtained through the agency of a leguminous crop.—(R. S. Finlow.)

*
* *

THE EFFECT OF CHANGE OF CLIMATE ON THE JUICE OF SUGARCANE.—One of the effects of transplanting sugarcane to another country or climate is, at times, a decrease in the richness of the juice. This is not uniformly so. For example, canes called "Wine coloured," "Vizianagram," "White Seema" and "Namali," which were imported from the Samalkota Agricultural Station to Pusa in 1904, have contained as rich juice in the new as in the former region. The percentage of cane sugar in the juice of these varieties as grown at Pusa has been 21·3, 18·1 and 25·4. But in other cases the plant does not grow at first in the same perfect manner and two

Mauritius varieties may be instanced. These were imported by the Bombay Department (*vide* Agricultural Ledger, 1896, No. 19, page 3) in 1894, the one a red thick and the other a white thick cane, and they had the reputation of containing some 18% of sugar in the juice. The red variety in 1896 contained only 10% of cane sugar and 2% of glucose in the juice, whilst the white variety contained about 12% and 1·4% respectively. In 1897 they were analysed again, when the red variety yielded juice containing 12·7% of cane sugar and 1·5% of glucose, and the white variety 14·71% and ·99% respectively (Agricultural Ledger, 1897, No. 3, page 8). They were again tested at Poona in 1901, when the juice of the red variety contained 13% sugar and 2% of glucose, and the white variety 13·5 of cane sugar and 1·2% of glucose. Thus, whilst there was a fairly steady increase, it had not reached the supposed original standard in seven years. They were brought to Pusa in 1904 and have grown perfectly there. The red variety in the crop of 1905 contained 18·4% cane sugar and ·5% glucose in the juice ; the juice of the white variety contained 21·1% of cane sugar and ·3% glucose in 1905. The effect of climate on juice is no doubt very considerable at times.—(J. W. Leather).

*
* *

EFFECT OF CHANGE OF CLIMATE ON THE AMOUNT OF OIL IN LINSEED.— An examination of oil seeds from various Provinces of India, which was made in 1903-04, showed that some specimens of the same oil-seed contained much more oil than others. Linseed formed no exception to the general rule, and the Punjab Agricultural Department obtained specimens of six varieties which had proved to be rich in other Provinces. These have been cultivated at Lyallpur in 1904-05 and 1905-06. The following statement shows the amount of oil in the linseed (*a*) as received at Lyallpur, (*b*) produced in 1904-05 and (*c*) in 1905-06.

	(*a*) Original seed.	(*b*) Crop of 1904-05.	(*c*) Crop of 1905-06.
White, from Cawnpore	44·62	41·28	39·90
„ „ Khandesh	44·96	44·18	42·93
„ „ Damoh	45·34	43·07	43·57
Red-brown, from Partapgarh ...	43·17	40·98	38·31
Brown, from Cawnpore	42·05	40·97	39·43
„ „ Sholapur	41·13	40·42	38·82

The net result seems to be a general decline in the amount of oil, though it is not very great. The Punjab varieties were found to be generally somewhat poorer in oil than those of other Provinces, and it may be that the climate has a definite influence on the amount of this constituent in the

linseed. On the other hand, the Punjab oil seeds are not generally characterised by low percentages of oil.—(J. W. Leather).

***

CALCIUM CYANAMIDE.—Information regarding the value of this nitrogenous fertilizer continues to accumulate. During the past year, records of experiments with it have appeared from Rothamsted and from some of the German Experiment Stations, and a résumé of those undertaken at Marburg and Breslau is found in the Journal of the Board of Agriculture, London, XIII, 1906, pages 38-43. At each station the same effect of the substance on the germination was noticed ; if the seed was sown at the same time as the manure, germination was retarded, whilst if a period of a couple of weeks is allowed from the date of the application of the manure before sowing the seed, no retarding effect is noticeable. In the after-growth the effect of the fertilizer is nearly as great as that of nitrate of soda. The results of a second year's trials at Rothamsted (Journal of the Board of Agriculture, London, XIII, 1906, pages 216-218) with barley and mangels, have shown it to be practically equal to sulphate of ammonia, each of the crops growing to perfection.

In some preliminary trials which I made of the value of this substance, the results last year coincided with the experience of others, the germination of the seed sown with the manure being retarded, whilst no such effect was noticed if a week elapsed between application of the manuring and sowing the seed. This year the cyanamide did not produce this result at all. The after-growth is apparently quite as good as when other manures are employed.—(J. W. Leather.)

***

THE POTASH DEPOSITS OF GERMANY.—The Journal of the Board of Agriculture gives some interesting information concerning the potash deposits of Germany. These well-known deposits of potash salts, which are situated at Magdeburg, Anhalt, Hanover, Brunswick and Thuringen, were first discovered in 1839, but their agricultural value was only appreciated later, and a factory was built in 1861 at Stassfurt for the production of potassium chloride. Since then the production has increased enormously. In 1885 the amount used for agricultural purposes was 1,375,000 cwt. ; in 1895 it had grown to 9,593,000 cwt., and in 1903 the corresponding figure was 20,836,000 cwt. It is calculated that the average amount of potash applied to the land in this form in Germany was 69 lbs. per 100 acres in 1890, and is now 392 lbs. per 100 acres. The exports have risen from 9,215,000 cwt. in 1900 to 12,433,000 cwt. in 1904. The United States of America take rather more than one-half of this.—(J. W. Leather.)

RUBBER EXPERIMENTS IN BOMBAY.—In our last issue (page 263) we noticed the arrangements proposed for making tests of rubber-yielding plants in the Bombay Presidency. The Bombay Government has since published some further interesting papers concerning these trials. Mr. Coplestone, Deputy Conservator of Forests, was deputed to Ceylon to study the question, and his report gives some useful information. Dealing with the rubber-yielding plants tested in Ceylon, he summarizes his conclusions as follows :—

"(*a*) Though *Ficus elastica* grows very rapidly and to a huge size, it is not considered a valuable rubber tree in Ceylon, and the Peradeniya experts have never recommended cultivating it. This Ficus grows to a far greater size and more rapidly than it does in Belgaum.

(*b*) *Castilloa* is also unsatisfactory. The latex from it is very difficult to coagulate, and planters are not cultivating it to any extent.

(*c*) The *Ceara* is also not generally cultivated now and is looked upon as a failure in Ceylon. The tree grows everywhere, and it spreads by natural seedlings and is easily propagated by cuttings. It yields excellent rubber, but usually dies off after tapping. It can only stand very light tappings with long periods of rest, so that the yield per tree seldom exceeds ½lb. per annum. The general opinion in Ceylon is that the tree is not worth cultivating. On the well-known Culloden estate at Neboda (Kalutara), all the *Ceara* trees were felled and removed to make room for *Para.*

(*d*) & (*e*) *Kicksia* and *Funtumia* are not cultivated, and no rubber has been obtained from the specimens in the Peradeniya gardens.

(*f*) *Hevea Braziliensis.*—This is the only kind of rubber cultivated extensively in Ceylon. It is a hardy tree which will grow on any soil. It thrives even on steep, rocky hills, growing in the cracks between the gneiss rocks. It is also found growing well on 'Kabook,' a wretchedly poor gravelly iron soil, which is considered useless and even too poor for cultivating ragi, etc. The *Para* stands any amount of tapping and will yield rubber continuously throughout the year : the yield of a five-year old tree averages 1 lb. per annum, and this yield rapidly increases to 10 lbs. per tree, and some 25 years old trees at Culloden and Heneratgoda were yielding 25 lbs. of rubber a year.

The yields from *Ficus elastica*, *Castilloa* and *Ceara* are meagre in comparison with that of *Para*, and with such extensive plantations of *Para*, which will be coming into bearing within five years time, the prospects for the former three species are poor, and it appears that *Para* rubber will swamp the market and drive out the other three species."

Mr. Coplestone next discusses the climatic requirements for the cultivation of *Para* rubber. He states that it requires a moist, steamy climate

with an average temperature of about 80°, and a range of 65° to 95°. The temperature of the Kanara forests appears to be ideal for rubber cultivation, but the gravest doubts are expressed concerning the suitability of the rainfall. The best rubber-growing districts of Ceylon have an average annual rainfall varying from 80 to 170 inches, which is evenly distributed throughout the year. At the Experiment Station of Maha-Illupalama, the annual rainfall is 43 inches, the months of June, July and August being almost dry. 'Here we have practically no rain for three consecutive months, and this break is too much for the *Para*. The leaves of the *Para* here shrivel up from the dry wind, and even with irrigation and in very dry soil it does not thrive with this rainfall.' Mr. Coplestone then points out that for five and often for six consecutive months, there is no rain in Kanara, and that the degree of humidity is not high. He considers that the prospects of getting a good yield of rubber are not favourable under such conditions, for it is improbable that latex would flow in the dry months, from November to May, whereas in Ceylon, tapping can be carried on throughout the year. 'Again in June, July and August, the rain is so heavy that the latex would be wasted away, and this reduces the tapping season to September and October.' The prospects are, therefore, not very promising, but in accordance with Mr. Coplestone's suggestion, the Bombay Government has sanctioned the establishment in Kanara of three experimental plantations of 20 acres each with *Para*, *Castilloa* and *Ceara* respectively.—(F. G. Sly.)

*
* *

TRIAL OF NATAL WILD INDIGO.—Two packets of seed of wild indigo (*Ind. arrecta*), obtained by the Inspector-General of Agriculture from the Natal Department of Agriculture, were tested at the Pusa Experiment Station. The seed was sown under irrigation on the 23rd March 1905. Germination was not satisfactory, but the plants grew thereafter with a fair amount of vigour, although in this respect they did not compare with the Java acclimatized plant, grown alongside under the same conditions. The quantity was too small for manufacture, but the following is the result of Mr. Bergtheil's analysis :—

	Leaf content of Plant.	Content of Indigotin in Leaf.
	%	%
Java acclimatized ..	52·2	1·05
Natal wild ...	52·9	·667

The Natal wild indigo thus proved inferior to the Java acclimatized, both in weight of plant per unit of area and in percentage content of indigotin in leaf, but it must be remembered that this is only the result of one year's trial.—(E. Shearer.)

*
* *

THE GERMINATION OF JAVA INDIGO SEED. A CORRECTION.—Owing to a clerical error, the quantity of sulphuric acid recommended in our July number (p. 262), for treating half a maund of Java indigo seed to promote germination was 20 seers. This is erroneous; the correct quantity should be 5 seers.—(C. Bergtheil.)

*
* *

A NEW INSTITUTE OF COMMERCIAL RESEARCH IN THE TROPICS.—The objects of the Liverpool University Institute of Commercial Research in the tropics are given in the first number of its Quarterly Journal (January 1906) as follows :—

1. Collecting and tabulating information regarding raw products, natural resources, trades, industries, and economic conditions which can be of service either to commerce or science.

2. Studying the botany, zoology, geology, ethnology, meteorology and physiology of tropical countries especially in their relation to the development of British commerce.

3. Investigating all kinds of scientific problems which arise in connection with trade and industry.

4. Training experts in the various branches of applied science concerned.

5. Supplying scientific information and advice to all interested in commerce.

Four departments have been founded, namely :—(1) Statistics, Applied Economy and Geography; (2) Economic Botany; (3) Economic Zoology; (4) Economic Chemistry.—(A. Howard.)

NOTICE.

The Agricultural Journal of India.

A Quarterly Journal of Agriculture and Allied Subjects for the general reader interested in Agriculture and in Indian Agriculture.

Subscription ... Rs. 6-0-0 per annum in advance.
,, 2-0-0 per part.

CORRESPONDENCE concerning subscriptions, changes of address, delay in receipt of the Journal and such like matters should be addressed to MESSRS. THACKER, SPINK & CO., CALCUTTA.

Articles intended for publication should be sent to the Editor, the Inspector-General of Agriculture, Nagpur, Central Provinces, India. Contributors are invited to sign their contributions. All communications must be authenticated by the name and address of the writer, whether intended for publication or not. Contributors will be given, free of charge, fifty copies of their contributions, and will be supplied free with one year's issue of the Journal.